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ELEMENTS

OF

MINERALOGY;

CONTAINING

A GENERAL INTRODUCTION TO THE SCIENCE, WITH DESCRIPTIONS OF THE SPECIES.

REPRINTED FROM THE
EIGHTH EDITION OF THE ENCYCLOPÆDIA BRITANNICA.

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BY

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PREFACE.

In preparing the following Treatise, the author's design was to furnish a summary of the leading principles and more important facts of Mineralogy. Intended specially for the general student, and for persons studying this science with a view to its practical applications to geology, mining, and other connected pursuits, these facts and principles are explained in the simplest language consistent with scientific accuracy, and the results of the most important chemical analyses and other investigations are stated, without those details which often prove more embarrassing than useful to the beginner.

The general plan, and a considerable part of the materials, are derived from the author's Manual of Mineralogy. His experience in teaching the science has convinced him that a mixed system of classification, such as is there employed, not only admits of a more natural grouping of the species, but is far better fitted to promote the progress of the student, than either a rigid chemical or crystallo-

graphical arrangement. He also still retains Professor Naumann's system and symbols of crystallography, as in his opinion not only simpler and more philosophical than any other hitherto proposed, but as the most generally useful in consulting the best works on this science.

As his plan does not admit of references to the many memoirs and treatises consulted, the author deems it necessary to state that he has endeavoured to obtain the latest and best information on the subject. He must specially acknowledge the valuable assistance derived from the works of Naumann, Hausmann, Rammelsberg, and G. Rose. Besides such corrections and improvements in the classification and descriptions as recent investigations or change of views have rendered necessary, general characters of the orders and families under which the species are classified have now been introduced. As a guide to the private student, those families and species are indicated by an asterisk (*) which, either from their frequent occurrence, geological importance, or economic properties, are most worthy of attention. In conclusion, the author trusts that this Treatise may, in some measure, promote —what has been his chief object in preparing it— an increased knowledge of this most important and beautiful portion of the works of the Creator.

MARISCHAL COLLEGE,
1st *January* 1858.

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MINERALOGY.

MINERALOGY is sometimes understood as comprising the natural history of every portion of inorganic nature. Here we consider it as limited to the natural history of simple minerals or mineral species. In the strictest sense, a mineral species is a natural inorganic body, possessing a definite chemical composition, and assuming a regular determinate form or series of forms. This definition excludes many bodies often regarded as minerals: as, all the artificial salts of the chemists, all the inorganic secretions of plants and animals, all the remains of former living beings now imbedded in rocks. Some substances originally organic products have indeed, by common consent, found a place in mineral systems, as coal, amber, and mineral resins; but this is a departure from the strictness of the definition, and in most cases had perhaps better have been avoided. So also some amorphous substances, with no precise form or chemical composition, as some kinds of clay, have been introduced into works on mineralogy, but we believe often improperly, and with no beneficial result. Aggregates of simple minerals or rocks are likewise excluded from this science, though the various associations of minerals, their modes of occurrence, and their geological position, are important points in the history of the different species.

One most important object of a treatise on mineralogy should be to give such descriptions of minerals, their essential properties and distinctive characters, as will enable the student to distinguish the various species, and to recognise them when they occur in nature. But to accomplish this he must first become acquainted with the terminology or nomenclature of the science; that is, with the meaning of the terms used in describing these properties, and the various modifications they may undergo. With this is necessarily conjoined an account of the properties themselves, and of the more general laws by which their various changes are regulated. A second and closely-related portion of mineralogy is the system or classification, giving an account of the order in which the species are arranged, and the reasons for which it has been adopted. The third and most important part of mineralogy, to which these two are properly preparatory, is the physiography of the various species, giving an account of their characteristic marks, and a description of their appearance or external aspect and forms; their principal physical and chemical properties; their mode of occurrence, with their geological and geographical distribution; and their various uses, whether in nature or in the arts. Each of these departments will be considered in the following treatise in the order just mentioned.

PART I.

TERMINOLOGY.

CHAPTER I.

FORM OF MINERALS.

The physical properties of a mineral comprise all those properties belonging to it as a body existing in space, and consisting of matter aggregated in a peculiar way. The more important of these are,—its form as shown in crystallization; its structure as determining its mode of cleavage and fracture; its hardness and tenacity; its weight or specific gravity; and its relations to light, heat, electricity, and magnetism.

Crystalline and Amorphous.—Mineral substances occur in two distinct modes of aggregation. Some consist of minute particles simply collected together, with no regularity of structure or constancy of external form, and are named amorphous. All fluid minerals are in this condition, together with some solid bodies, which appear to have condensed either from a gelatinous condition like opal, when they are named *porodine*, or from a state of igneous fluidity like obsidian and glass, when they are named *hyaline*. The other class have their ultimate atoms evidently arranged according to definite law, and are named *crystalline*, when the regularity of structure appears only in the internal disposition of the parts; and *crystallized*, when it also produces a determinate external form, or a *crystal*.

CRYSTALS.

Faces, Edges, Angles, Axes of Crystals.—The word *crystal* in mineralogy designates a solid body exhibiting an original (not artificial) more or less regular polyhedric form. It is thus bounded by plane surfaces, named *faces*, which intersect in straight lines or *edges*, and these again meet in points and form *solid angles*, bounded by three or more faces. The space occupied by a crystal is often named a *form of crystallization*, which is thus the mathematical figure regarded as independent of the matter that fills it. Crystals bounded by equal and similar faces are named *simple forms;* whilst those in which the faces are not equal and similar are named *compound forms*, or *combinations*, being regarded as produced by the union or combination of two or more simple forms. The cube or hexahedron (fig. 1), bounded by six equal and similar squares; the octahedron (fig. 2), by eight equilateral triangles; and the rhombohedron, by six rhombs,—are thus simple forms. An *axis* of a crystal is a line passing through its centre and terminating either in the middle of two faces, or of two edges, or in two angles; and axes terminating in similar parts of a crystal are named similar axes. In describing a crystal, one of its axes is supposed to be vertical or upright, and is then named the *principal axis*, and that axis is chosen which is the only one of its kind in the figure. A few other technical terms used in describing crystals will be explained as they occur.

Systems of Crystallization.—The forms of crystals that occur in nature seem almost innumerable. On examining them, however, more attentively, certain relations are discovered even between highly complex crystals. When the axes are properly chosen, and placed in a right position, the various faces are observed to group themselves in a regular and beautiful manner around these axes, and to be all so related as to compose connected series produced according to definite laws. In every mineral species there is a certain

form of crystal from which, as a primary, every other form of crystal observed in that mineral species may be deduced. In each species the axes, bearing to each other definite numerical proportions, intersect at angles which are constant. So also the faces of the various forms are related to each other, and to their primary, according to certain definite laws. When viewed in this manner, and referred to their simplest forms, the innumerable variety of crystals occurring in nature may all be reduced to six distinct groups, or, as they are named, systems of crystallization. The following are the names given to these systems of crystallization in some of the best authors:—

Naumann.	Mohs.	Weiss and G. Rose.
1. Tesseral System.	Tessular.	Regular.
2. Tetragonal System.	Pyramidal.	2 and 1 axial.
3. Hexagonal System.	Rhombohedral.	3 and 1 axial.
4. Rhombic System.	Orthotype.	1 and 1 axial.
5. Monoclinohedric System.	Hemiorthotype.	2 and 1 membered.
6. Triclinohedric System.	Anorthotype.	1 and 1 membered.

In the following treatise the terminology of Naumann is adopted, his method of classifying and describing crystals appearing the simplest and best adapted to promote the progress of the student.

Holohedric and Hemihedric.—Before describing these systems, it must be observed that certain crystals appear as the half of others, and are therefore named *hemihedric;* whilst the crystals with the full number of faces are named *holohedric.* Hemihedric crystals are formed when the alternate faces or groups of faces of a holohedric crystal increase symmetrically, so as to obliterate the other faces. Thus, if four alternate faces of the octohedron increase so as to obliterate the other four, a tetrahedron with half the number of faces is formed.

I. The first, or *Tesseral System,* named from *tessera,* a cube, which is one of the most frequent varieties, is characterized by three equal axes intersecting each other at right

angles. Properly speaking, this system has no chief axis, as any one of them may be so named, and placed upright in drawing and describing the crystals. Of these there are thirteen varieties, which are thus classed and named from the number of their faces:—

1. One Tetrahedron, or form with four faces.
2. One Hexahedron, with six faces.
3. One Octahedron, with eight faces.
4. Four Dodecahedrons, with twelve faces.
5. Five Icositetrahedrons, with twenty-four faces.
6. One Tetracontaoctahedron, with forty-eight faces.

The dodecahedrons are further distinguished, according to the form of their faces, into rhombic, trigonal, deltoid, and pentagonal dodecahedrons; and some of the icositetrahedrons have also received peculiar names.

The following is a description, with figures, of the different forms above mentioned, beginning with

The *Holohedric forms.*

1. The hexahedron or cube (fig. 1) is bounded by six equal squares, has twelve edges, formed by faces meeting

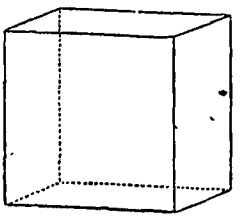


Fig. 1.

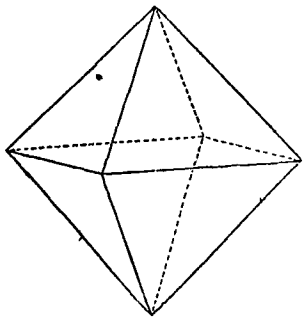


Fig. 2.

at 90°, and eight trigonal angles. The principal axes join the centre points of any two opposite faces.—Examples are fluor spar, galena, boracite.

2. The octahedron (fig. 2), bounded by eight equilateral

triangles, has twelve equal edges, with planes meeting at 109° 28′, and six tetragonal angles. The principal axes join the opposite angles, two and two.—Example, alum, spinel, magnetic iron ore.

3. The rhombic-dodecahedron (fig. 3) is bounded by twelve equal and similar rhombs (diagonals as 1 and $\sqrt{2}$),

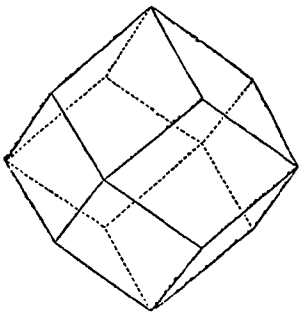


Fig. 3.

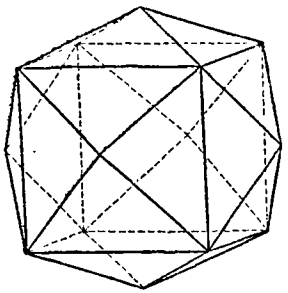


Fig. 4.

has twenty-four equal edges of 120°, and six tetragonal and eight trigonal angles. The principal axes join two opposite tetragonal angles.—Ex., garnet, boracite.

4. The tetrakishexahedrons (variety of icositetrahedron, fig. 4), are bounded by twenty-four isosceles triangles, arranged in six groups of four each. They have twelve longer edges which correspond to those of the primitive or inscribed cube, and twenty-four shorter edges placed over each of its faces. The angles are eight hexagonal and six tetragonal; the latter joined two and two by the three principal axes. This form varies in general aspect, approaching, on the one hand, to the cube; on the other, to the rhombic-dodecahedron.—Ex., fluor spar, gold.

5. The triakisoctahedrons (variety of icositetrahedron, fig. 5), are bounded by twenty-four isosceles triangles, in eight groups of three, and, like the previous form, vary in general aspect from the octahedron on one side, to the rhombic-dodecahedron on the other. The edges are twelve

longer, corresponding with those of the inscribed octahedron, and twenty-four shorter, three and three over each of the faces. The angles are eight trigonal and six ditetragonal (formed by eight faces); the latter angles joined two and two by the principal axes.—Ex., galena, diamond.

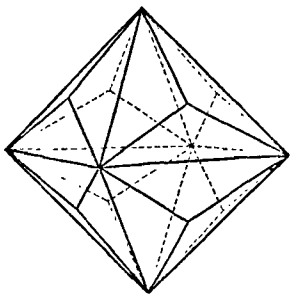


Fig. 5.

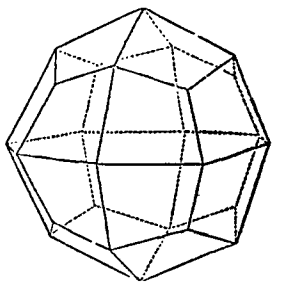


Fig. 6.

6. The icositetrahedrons (most common variety, fig. 6) are bounded by twenty-four deltoids or figures with four sides, of which two and two adjacent ones are equal. This form varies from the octahedron to the cube, sometimes approaching the former and sometimes the latter in general aspect. The edges are twenty-four longer and twenty-four shorter. The angles are six tetragonal joined by the principal axes, eight trigonal, and twelve rhombic, or tetragonal with unequal angles.

7. The hexakisoctahedrons (fig. 7), bounded by forty-eight scalene triangles, vary much in general aspect, approaching more or less to all the preceding forms; but most frequently they have the faces arranged either in six groups of eight, or eight of six, or twelve of four faces. There are twenty-four long edges, often corresponding to those of the rhombic-dodecahedron; twenty-four intermediate edges lying in pairs over each edge of the inscribed octahedron; and twenty-four short edges in pairs over the edges of the inscribed cube. There are six ditetragonal

angles joined by the principal axes, eight hexagonal and twelve rhombic angles.—Ex., fluor spar, garnet, diamond.

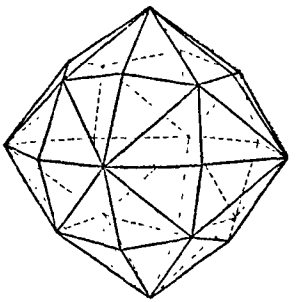


Fig 7.

The seven forms of crystals now described are related to each other in the most intimate manner. This will appear more distinctly from the following account of the derivation of the forms, with which is conjoined an explanation of the crystallographic signs or symbols by which they are designated. We have adopted these symbols throughout this work, in the belief that they not only mark the forms in a greatly abbreviated manner, but also exhibit the relations of the forms and combinations in a way which words could hardly accomplish.

The *derivation of forms* is that process by which, from one form chosen for the purpose, and considered as the *type*—the *fundamental* or *primary form*—all the other forms of a system may be produced, according to fixed principles or general laws. In order to understand this process or method of derivation, the student should keep in mind that the position of any plane is fixed when the positions of any three points in it, not all in one straight line, are known. To determine the position, therefore, of the face of a crystal, it is only necessary to know the distance of three points in it from the centre of the crystal, or the points in which the face or its supposed extension would intersect the three

axes of the crystal. The portion of the axes between this point and the centre are named parameters, and the position of the face is sufficiently known when the relative length or proportion of these parameters is ascertained. When the position of one face of a simple form is thus fixed or described, all the other faces are in like manner fixed, since they are all equal and similar, and all intersect the axes in a uniform manner; and the expression which marks or describes one face, marks and describes the whole figure.

The octahedron is generally adopted as the primary or fundamental form of the tesseral system, and distinguished by the first letter of the name, O. Its faces cut the half axes at equal distances from the centre; so that these semiaxes, or the parameters of the faces, have to each other the proportion 1 : 1 : 1. In order to derive the other forms from the octahedron, the following construction is employed. The numbers refer to the descriptions above.

Suppose a plane so placed in each angle of the octahedron as to be vertical to the axis passing through that angle, and consequently parallel to the two other axes (or to cut them at an infinite distance = ∞); then the hexahedron or cube (1) is produced, designated by the crystallographic sign ∞ O ∞; expressing the proportion of the parameters of its faces, or $\infty : \infty : 1$. If a plane is supposed placed in each edge parallel to one axis, and cutting the two other axes at equal distances, the resulting figure is the rhombic-dodecahedron (3), designated by the sign ∞O, the proportion of the parameters of its faces being $\infty : 1 : 1$. The triakisoctahedron (5) arises when on each edge of the octahedron planes are placed cutting the axis not belonging to that edge at a distance from the centre m which is a rational number greater than 1. The proportion of its parameters is therefore $m : 1 : 1$, and its sign mO; the most common varieties being $\frac{3}{2}$O, 2O, and 3O. When, on the other hand, from a similar distance m in each two semiaxes pro-

longed, a plane is drawn to the other semiaxis, or to each angle, an ikositetrahedron (6) is formed; the parameters of its faces have consequently the proportion $m : 1 : m$, and its sign is mOm; the most common varieties being 2O2 and 3O3, the former very frequent in leucite, analcime, and garnet. When, again, planes are drawn from each angle, or the end of one semiaxis of the octahedron, parallel to a second axis, and cutting the third at a distance n, greater than 1, then the tetrakishexahedron (4) is formed, the parameter of its faces $\infty : 1 : n$; its sign ∞On; and the most common varieties in nature $\infty O\frac{3}{2}$, $\infty O2$, and $\infty O3$. Finally, if in each semiaxis of the octahedron two distances, m and n, be taken, each greater than 1, and m also greater than n, and planes be drawn from each angle to these points, so that the two planes lying over each edge cut the second semiaxis belonging to that edge, at the smaller distance n, and the third axis at the greater distance m, then the hexakisoctahedron (7) is produced, the parameters of which are $m : n : 1$, its sign mOn, and the most common varieties $3O\frac{3}{2}$, 4O2, and $5O\frac{5}{2}$.

The next class of crystals are the *semi-tesseral forms*; and first, those with oblique faces, often named tetrahedral, from their relation to the tetrahedron. (1.) This form (fig. 8)

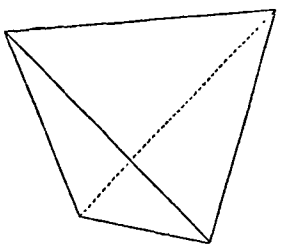


Fig. 8.

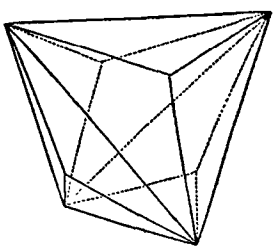


Fig. 9.

is bounded by four equilateral triangles, has six equal edges with faces meeting at 70° 32′, and four trigonal angles. The principal axes join the middle points of each two op-

posite edges.—Ex., gray-copper ore, boracite, and helvine. (2.) The trigonal dodecahedrons (fig. 9) are bounded by twelve isosceles triangles, and vary in general form from the tetrahedron to the hexahedron. There are six longer edges corresponding to those of the inscribed tetrahedron, and twelve shorter, placed three and three over each of its faces; and four hexagonal and four trigonal angles.—Ex., gray-copper ore, and bismuth-blende. (3.) The deltoid-dodecahedrons (fig. 10) are bounded by twelve deltoids, and vary in general form from the tetrahedron on the one hand, to the rhombic-dodecahedron on the other. They have twelve longer edges lying in pairs over the edges of the inscribed tetrahedron; and twelve shorter edges, three and three over each of its faces. The angles are six tetra-

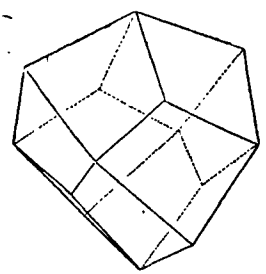


Fig. 10.

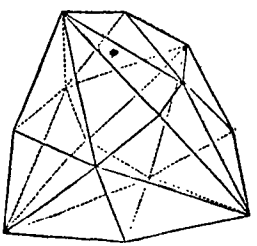


Fig. 11.

gonal (rhombic), four acute trigonal, and four obtuse trigonal angles. The principal axes join two and two opposite rhombic angles.—Ex., gray-copper ore. (4.) The hexakistetrahedrons (fig. 11) are bounded by twenty-four scalene triangles, and most commonly have their faces grouped in four systems of six each. The edges are twelve shorter and twelve longer, lying in groups of three over each face of the inscribed tetrahedron, and twelve intermediate in pairs over its edges. The angles are six rhombic, joined in pairs by the principal axes, and four acuter and four obtuser hexagonal angles.—Ex., diamond.

The derivation and signs of these forms are as follows:—. The tetrahedron arises when four alternate faces of the octahedron are enlarged, so as to obliterate the other four, and its sign is hence $\frac{O}{2}$. But, as either four faces may be thus enlarged or obliterated, two tetrahedrons can be formed similar in all respects except in position, and together making up the octahedron. These are distinguished by the signs + and −, added to the above symbol, but only the latter in general expressed thus $-\frac{O}{2}$. In all hemihedric systems two forms similarly related occur, which may thus be named complementary forms. The trigonal dodecahedron is derived from the icositetrahedron by the expansion of the alternate trigonal groups of faces. Its sign is $\frac{mOm}{2}$, the most common variety being $\frac{2O2}{2}$, found in gray-copper ore. The deltoid-dodecahedron is in like manner the result of the increase of the alternate trigonal groups of faces of the triakisoctahedron, and its sign is $\frac{mO}{2}$. Lastly, the hexakis-tetrahedron arises in the development of alternate hexagonal groups of faces in the hexakisoctahedron, and its sign is $\frac{mOn}{2}$.

The parallel-faced semitesseral forms are two. (1.) The pentagonal dodecahedrons (fig. 12) are bounded by twelve symmetrical pentagons, and vary in general aspect between the hexahedron and rhombic-dodecahedron. They have six regular (and in general longer) edges, lying over the faces of the inscribed hexahedron, and twenty-four generally shorter (seldom longer) edges, usually lying in pairs over its edges. The angles are eight of three equal angles, and twelve of three unequal angles. Each principal axis unites two opposite regular edges. This form is

derived from the tetrakishexahedron, and its sign is $\frac{\infty On}{2}$, one of the most common varieties being $\frac{\infty O2}{2}$, found frequently in iron pyrites and cobaltine. (2.) The dyakisdodecahedron (fig. 13), bounded by twenty-four trapezoids

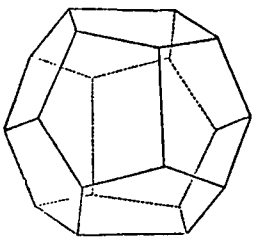


Fig. 12.

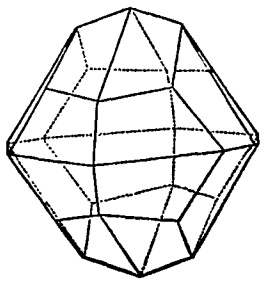


Fig. 13.

with two sides equal, has twelve short, twelve long, and twenty-four intermediate edges. The angles are six equiangular rhombic, united in pairs by the principal axes, eight trigonal, and twenty-four irregular tetragonal angles. It is derived from the hexakisoctahedron, and its sign is $\left[\frac{mOn}{2}\right]$, the brackets being used to distinguish it from the hexakistetrahedron; also derived from the same primary form. It occurs in iron pyrites and cobaltine. There are two other tetrahedral forms, the pentagonal dodecahedron (fig. 14), and

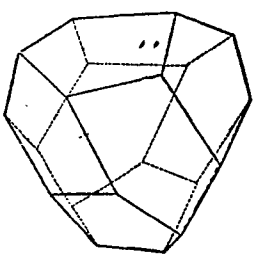


Fig. 14.

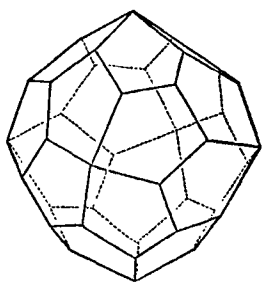


Fig. 15.

the pentagonal icositetrahedron (fig. 15), both bounded by irregular pentagons, but not yet observed in nature.

Combinations.—These forms of the tesseral system (and this is true also of the five other systems of crystallization) not only occur singly, but often two, three, or more are united in the same crystal, forming what are named combinations. In this case it is evident that no one of the individual forms can be completely developed, because the faces of one form must partially interfere with the faces of the other forms. A combination therefore implies that the faces of one form shall appear symmetrically disposed between the faces of other forms, and consequently in the room of certain of their edges and angles. These edges and angles are thus, as it were, cut off, and new ones produced in their place, which properly belong neither to the one form nor the other, but are edges or angles of combination. Usually, one form predominates more than the others, or has more influence on the general aspect of the crystal, and hence is distinguished as the predominant form, the others being named subordinate. The following terms used on this subject require explanation. A combination is *developed* when all the forms contributing to its formation are pointed out; and its sign consists of the signs of these forms, written in the order of their influence on the combination, with a point between. An angle or edge is said to be *replaced* when it is cut off by one or more secondary planes; it is *truncated* when cut by one plane, forming equal angles with the adjacent faces; and an edge is *bevelled* when replaced by two planes, which are equally inclined to the adjacent faces.

It will be readily seen that such combinations may be exceedingly numerous, or rather infinite; and only a few of the more common can be noticed, simply as specimens of the class. Many others more complicated will occur in the descriptive part of this treatise. Among plenotesseral combinations, the cube, octahedron, and also the rhombic-dodecahedron, are the predominant forms. In fig. 16 the

cube has its angles replaced by the faces of the octahedron, and the sign of this combination is $\infty O \infty$. O. In fig. 17

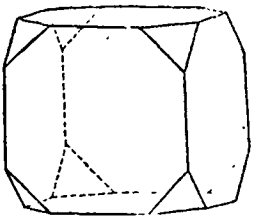


Fig. 16.

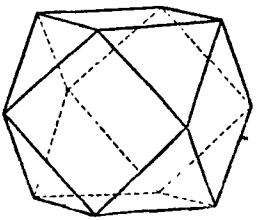


Fig. 17.

this process may be regarded as having proceeded still further, so that the faces of the octahedron now predominate, and the sign, of the same two elements but in reverse order, is O . $\infty O \infty$. In fig. 18 the cube has its edgesre placed by the faces of the rhombic-dodecahedron, the sign being $\infty O \infty$. ∞O; whilst in fig. 19 there is the same combina-

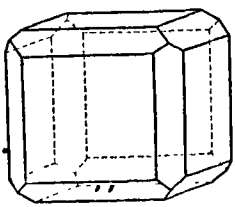


Fig. 18.

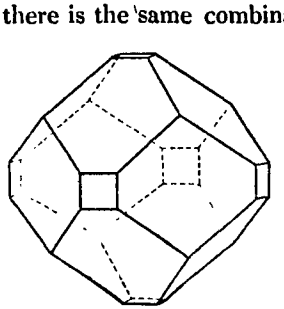


Fig. 19.

tion, but with the faces of the cube subordinate, and hence the symbol is ∞O. $\infty O \infty$. The former figure, it will be seen, has more the general aspect of the cube; the latter of the dodecahedron.

In combinations of semitesseral forms with oblique faces, the tetrahedron, the rhombic-dodecahedron, or even the hexahedron, seldomer a trigonal-dodecahedron, are the more common predominant forms. In fig. 20 two tetrahedrons

in opposite positions, $\frac{O}{2} \cdot -\frac{O}{2}$, are combined. In fig. 21 a

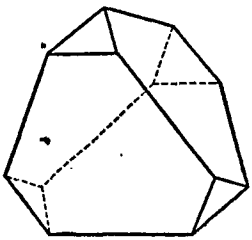


Fig. 20.

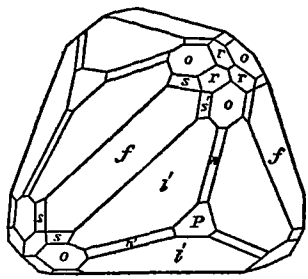


Fig. 21.

very complex combination of seven forms is represented in a crystal of grey-copper ore, its full sign being—

$$\frac{202}{2}(l') \cdot \infty O\infty(f) \cdot \infty O(o) \cdot \frac{O}{2}(P) \cdot -\frac{202}{2}(r) \cdot \frac{\frac{3}{2}O}{2}(n') \cdot \infty O3(s);$$

the letters in brackets connecting them with the respective faces of the figure. As examples of combinations of semi-tesseral forms with parallel faces, we may take fig. 22, in

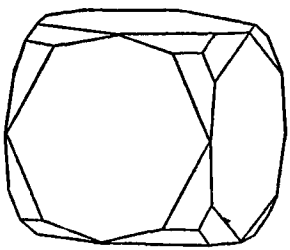


Fig. 22.

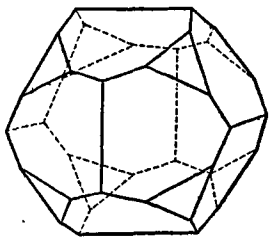


Fig. 23.

which each of the angles of the cube is unsymmetrically replaced by three faces of the dyakisdodecahedron, and hence $\infty O\infty \cdot \left[\frac{402}{2}\right]$; or fig. 23, in which the pentagonal-dodecahedron has its trigonal angles replaced by the faces of the octahedron, consequently with the sign $\frac{\infty O2}{2} \cdot O$.

Figure 24 represents the same combination but with greater predominance of the faces of the octahedron, the crystal being bounded by eight equilateral and twelve isosceles triangles.

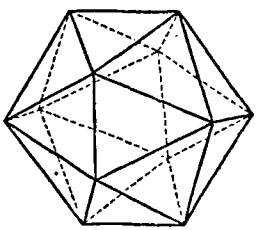


Fig. 24.

II. *Tetragonal System.*—This system has three axes at right angles, two of them equal and one unequal. The last is the principal axis, and when it is brought into a vertical position the crystal is said to be placed upright. Its ends are named poles, and the edges connected with them polar edges. The two other axes are named subordinate or lateral axes, and a plane passing through them is named the basis of the crystal. The two planes that pass through the principal and one of the lateral axes are named normal chief sections, and a plane through the chief axis intermediate to them a diagonal chief section. The name tetragonal is derived from the form of the basis, which is usually quadratic.

There are eight tetragonal forms, of which five are *closed*, —that is, bounded on all sides by planes, and of definite extent,—and three *open*, which in certain directions are not bounded, and consequently of indefinite extent.

The description of the varieties is as follows, it being premised that a crystallographic pyramid is equivalent to two geometrical pyramids joined base to base. *Closed forms.*—(1.) Tetragonal pyramids (figs. 25, 26) are inclosed by eight isosceles triangles, with four middle edges all in one plane, and eight polar edges. There are three kinds of this form, distinguished by the position of the lateral axes. In the first these axes unite the opposite angles; in the second they intersect the middle edges equally; and in the third they lie in an intermediate position, or divide these edges unequally; the latter being hemihedral forms. These pyramids are also distinguished as

obtuse (fig. 25) or acute (fig. 26), according as the vertical angle is greater or less than in the octahedron, which,

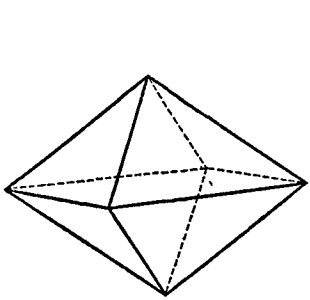


Fig. 25.

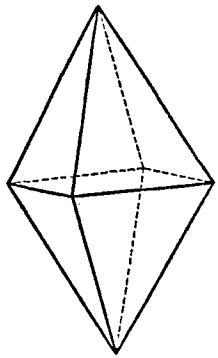


Fig. 26.

though intermediate, is never a tetragonal form. (2.) Ditetragonal pyramids (fig. 27) are bounded by sixteen scalene triangles, whose base lines are all in one plane. This form rarely occurs except in combinations. (3.) Tetragonal sphenoids (fig. 28), bounded by four isosceles

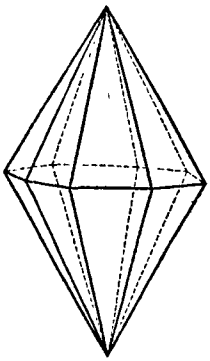


Fig. 27.

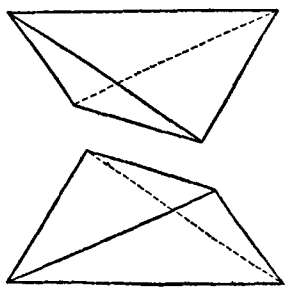


Fig. 28.

triangles, are the hemihedral forms of the first variety of tetragonal pyramids. (4.) The tetragonal scalenohedron

(fig. 29), bounded by eight scalene triangles, whose bases rise and fall in a zig-zag line, is the hemihedral form of the ditetragonal pyramid. The latter two forms are rare.

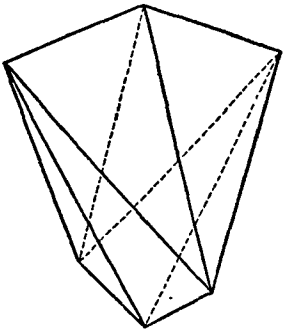


Fig. 29.

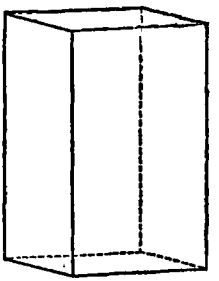


Fig. 30.

Open forms.—Tetragonal prisms (fig. 30) bounded by four planes parallel to the principal axis; ditetragonal prisms by eight similar planes. In these prisms the principal axis is supposed to be prolonged infinitely, or to be unbounded. Where it is very short and the lateral axes infinite, the basal pinacoid is formed, consisting merely of two parallel faces.

The various series of tetragonal crystals are distinguished from each other only by their relative dimensions. To determine these, one of the series must be chosen as the fundamental form, and for this purpose a tetragonal pyramid of the first variety, designated by P as its sign, is selected. The angle of one of its edges, especially the middle edge, found by measurement, determines its angular dimensions; whilst the proportion of the principal axis (a) to the lateral axes supposed equal to 1, gives its linear dimensions. The parameters, therefore, of each face of the fundamental form are $1 : 1 : a$.

Now if m be any (rational) number, either less or greater than 1, and if from any distance ma in the principal axis

planes be drawn to the middle edge of P, then new tetragonal pyramids of the first kind, but more or less acute or obtuse than P, are formed. The general sign of these pyramids is mP, and the most common varieties $\frac{1}{2}$P, 2P, 3P; with the chief axis equal to $\frac{1}{2}$, twice or thrice that of P. If m becomes infinite, or $= \infty$, then the pyramid passes into a prism, indefinitely extended along the principal axis, and with the sign ∞P; if $m = 0$, which is the case when the lateral axes are supposed infinite, then it becomes a pinacoid, consisting properly of two basal faces, open towards the lateral axes, and designated by the sign 0P. The ditetragonal pyramids are produced by taking in each lateral axis distances n greater than 1, and drawing two planes to these points from each of the intermediate polar edges. The parameters of these planes are therefore $m : 1 : n$, and the general sign of the form mPn, the most common values of n being $\frac{3}{2}$, 2, 3, and ∞. When $n = \infty$, a tetragonal pyramid of the second kind arises, designated generally by mP∞, the most common in the mineral kingdom being P∞ and 2P∞. The relation of these to pyramids of the first

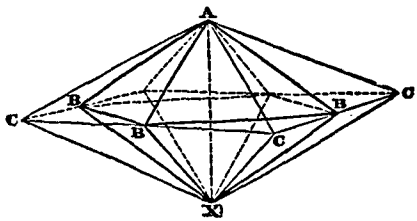


Fig. 31.

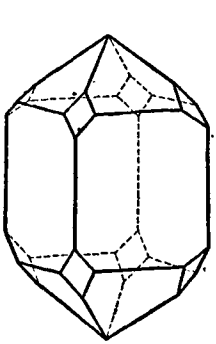


Fig. 32.

kind is shown in fig. 31, where ABBBX is the first, and ACCCX the second kind of pyramid. In like manner from the prism ∞P, the ditetragonal prisms ∞Pn are derived, and

finally when $n = \infty$, the tetragonal prism of the second kind, whose sign is $\infty P\infty$.

The combinations of the tetragonal system are either holohedric or hemihedric; but the latter are rare. Prisms and pinacoids must always be terminated on the open sides by other forms. Thus in fig. 32 a square prism of the first kind is terminated by the primary pyramid, and has its lateral angles again replaced by another more acute pyramid of the second kind, so that its sign is $\infty P . P . 2P\infty$. In fig. 33 a prism of the second kind is first bounded by

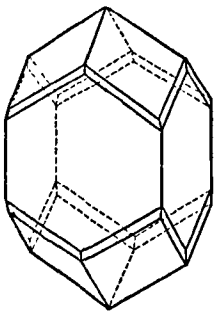


Fig. 33.

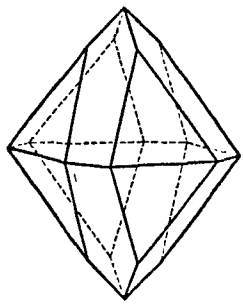


Fig. 34.

the fundamental pyramid, and then has its edges of combination replaced by a ditetragonal pyramid, and its sign is here $\infty P\infty . P' . 3P3$. In fig. 34 the polar edges of the pyramid are replaced by another pyramid, its sign being $P . P\infty$. In fig. 35 a hemihedric form very characteristic of copper pyrites is represented, P and P′ being the two sphenoids, *a* the basal pinacoid, and *b*, *c*, two ditetragonal pyramids.

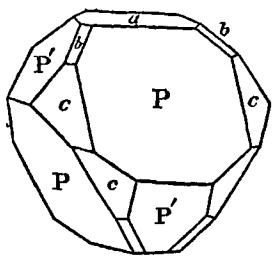


Fig. 35.

III. *The Hexagonal System.*—The essential character of this system is, that it has four axes,—three equal lateral axes

intersecting each other in one plane at 60°, and one principal axis at right angles to them. The extremities of the principal axis are named poles, and sections through it and one lateral axis, normal chief sections. The plane through the lateral axes is the basis, and from its hexagonal form gives the name to the system. As in the last system, its forms are either *closed* or *open;* and are divided into holohedral, hemihedral, and tetartohedral,—the last forms with only a fourth part of their faces developed. The tetartohedral and many of the hemihedral forms are of rare occurrence, and only a few of the more common require to be here described.

The hexagonal pyramids (figs. 36, 37) are bounded by twelve isosceles triangles, and are of three kinds, according

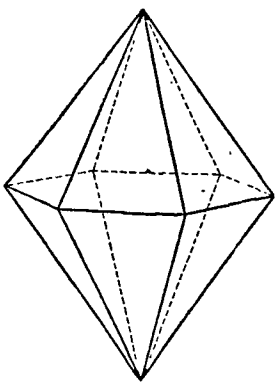


Fig. 36.

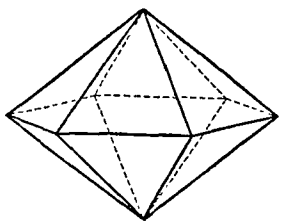


Fig. 37.

as the lateral axes fall in the angles, in the middle of the lateral edges, or in another point of these edges, the latter being hemihedral forms. They are also classed as acute or obtuse, but without any very precise limits. The trigonal pyramid is bounded by six triangles, and may be viewed as the hemihedral form of the hexagonal. The dihexagonal pyramid is bounded by twenty-four scalene triangles, but has never been observed alone, and rarely even in com-

binations. The more common prisms are the hexagonal of six sides, and the dihexagonal of twelve sides.

As the fundamental form of this system, a particular pyramid P is chosen, and its dimensions determined either from the proportion of the lateral to the principal axis ($1 : a$), or from the measurement of its angles. From this form (mP) others are derived exactly as in the tetragonal system. Thus dihexagonal pyramids are produced with the general sign mPn, the chief peculiarity being that, whereas in the tetragonal system n might have any rational value from 1 to ∞, in the hexagonal system it can only vary from 1 to 2, in consequence of the geometric character of the figure. When $n = 2$ the dihexagonal changes into an hexagonal pyramid of the second kind, whose sign is mP2. When m is $= \infty$ various prisms arise from similar changes in the value of n; and when $m = 0$, the basal pinacoid.

Few hexagonal mineral species form perfect holohedric combinations. Though quartz and apatite appear as such,

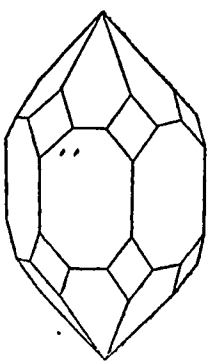


Fig. 38.

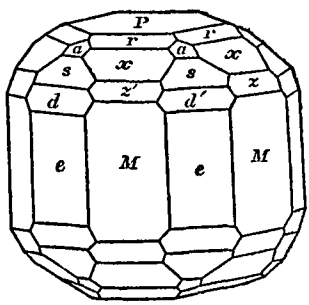


Fig. 39.

yet properly the former is a tetartohedral, the latter a hemihedral species. In holohedric species the predominant faces are usually those of the two hexagonal prisms ∞P

and ∞P2, or of the pinacoid 0P; whilst the pyramids P and 2P2 are the most common subordinate forms. Figure 38 represents the prism, bounded on the extremities by two pyramids; one, P, forming the point, the other 2P2 the rhombic faces on the angles, or ∞P . P . 2P2. In some crystals the lateral edges of the prism are replaced by the second prism ∞P2, producing an equiangular twelve-sided prism, which always represents the combination ∞P . ∞P2, and cannot occur as a simple form. An example of a more complicated combination is seen in fig. 39, of a crystal of apatite, whose sign with the corresponding letters is ∞ P(M) . ∞P2(e) . 0P(P) . $\frac{1}{2}$P(r) . P(x) . 2P(z) . P2(a) . 2P2(s) . 4P2(d).

Hexagonal minerals more frequently crystallize in those series of hemihedral forms that are named rhombohedral, from the prevalence in them of rhombohedrons. These are bounded by six rhombs (fig. 40), whose lateral edges do

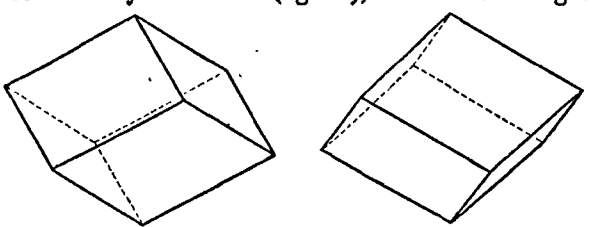


Fig. 40.

not lie in one plane, but rise and fall in a zig-zag manner. The principal axis unites the two trigonal angles, formed by three equal plane angles, and in the most common variety the secondary axes join the middle points of two opposite edges. When the polar edges form an angle of more than 90°, the rhombohedrons are named obtuse; when of less, acute. Hexagonal scalenohedrons (fig. 41) are bounded by twelve scalene triangles, whose lateral edges do not lie in one plane. The principal axis joins the two hexagonal angles, and the secondary axes the middle points of two opposite lateral edges.

The rhombohedron is derived from the first kind of hexagonal pyramid by the hemihedric development of its alternate faces. Its general sign should therefore be $\frac{m\mathrm{P}}{2}$; but on several grounds it is found better to designate it by R or mR, and its complimentary figure by $-m$R. When the prism or pinacoid arise as its limiting forms, they are designated by ∞R and 0R, though in no respect changed from the limiting forms ∞P and 0P of the pyramid. The scalenohedron is properly the hemihedric form of the dihexagonal pyramid, but is better derived from the inscribed rhombohedron mR. If the halves of the principal axis of this are multiplied by a definite number n,

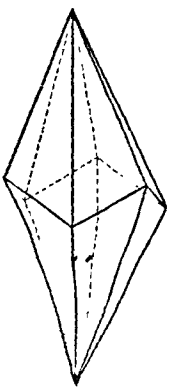


Fig. 41.

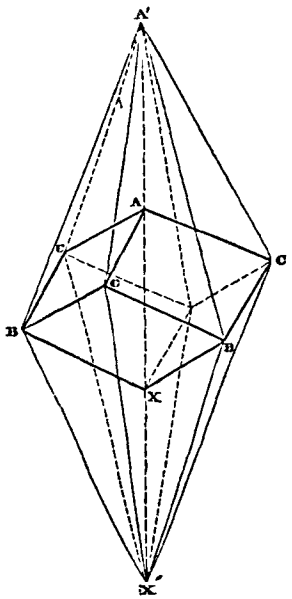


Fig. 42.

and then planes drawn from the extremities of this enlarged axis to the lateral edges of the rhombohedron, as in figure 42, the scalenohedron is constructed. Hence it is desig-

nated by $m\mathrm{R}^n$, the n being written on the right hand, like an algebraic exponent: and the dihexagonal prism is in like manner designated by $\infty\mathrm{R}^n$.

The combinations of rhombohedric forms are very numerous, some hundreds being described in calc-spar alone.

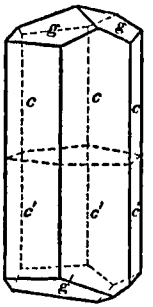


Fig. 43.

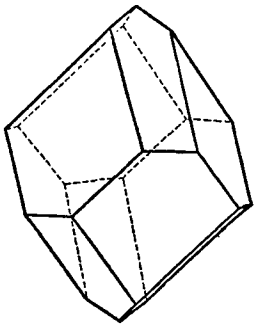


Fig. 44.

Among the more common is the prism in combination with a rhombohedron, as in the twin crystal of calc-spar (fig. 43), with the sign $\infty\mathrm{R}.-\frac{1}{2}\mathrm{R}$, the lower half being the same

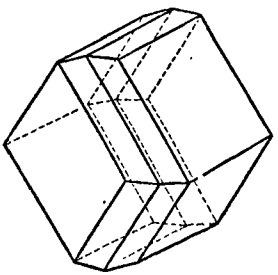


Fig. 45.

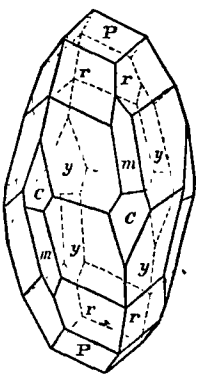


Fig. 46.

form with the upper, but turned round 180°. In figure 44, the rhombohedron $m\mathrm{R}$ has its polar edges replaced by another rhombohedron $-\frac{1}{2}m\mathrm{R}$; and in figure 45 its lateral

edges bevelled by the scalenohedron $m\mathrm{R}^n$. A more complex combination of five forms is represented in the crystal of calc-spar, fig. 46, its sign with the letters on the faces being $\mathrm{R}^5(y) . \mathrm{R}^3(r) . \mathrm{R}(P) . 4\mathrm{R}(m) . \infty\mathrm{R}(c)$. Tetartohedric combinations are seen most distinctly in pure quartz or rock-crystal, the pyramids of the first kind appearing as rhombohedrons, those of the second kind as trigonal pyramids, the dihexahedral prisms as ditrigonal prisms, and the prism $\infty\mathrm{P}2$ as a trigonal prism. Most of these forms, however, occupy but a very subordinate place in the combinations which consist essentially of the prism $\infty\mathrm{P}$, and the rhombohedron $\mathrm{R} = \frac{\mathrm{P}}{4}$.

IV. *Rhombic System.*—The rhombic system is characterized by three axes, all unequal, but at right angles to each other. One of these is assumed as the chief axis, when the others are named subordinate. The plane passing through the secondary axes, or the basis, forms a rhomb, and from this the name is derived. This system comprises only a few varieties of forms that are essentially distinct, and its relations are consequently very simple.

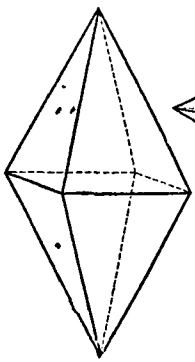


Fig. 47.

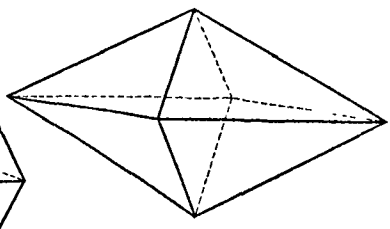


Fig. 48.

The *closed* forms are,—(1*st.*) The rhombic pyramids (figs. 47, 48), bounded by eight scalene triangles, whose

lateral edges lie in one plane, and form a rhomb. They have eight polar edges,—four acute and four more obtuse, —and four lateral edges, and six rhombic angles, the most acute at the extremities of the longest axis. (2*d.*) The rhombic sphenoids (fig. 49) are bounded by four scalene triangles with their lateral edges not in one plane; and are a hemihedric form of the rhombic pyramid of unfrequent occurrence. The *open* forms again are, —(3*d.*) Rhombic prisms bounded by four planes parallel to one of the axes which is indefinitely extended. They are divided into upright and horizontal prisms, according as either the principal or one of the lateral axes is supposed to become infinite. For the latter form the name *doma* or *dome* has been used; and two kinds, the macrodome and the brachydome, have been distinguished. Rhombic pinacoids also arise when one axis becomes=0, and the two others are indefinitely extended.

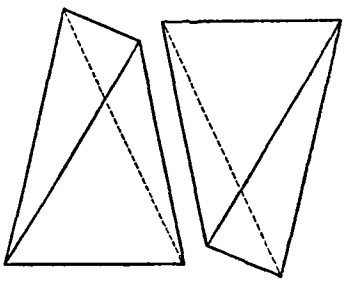


Fig. 49.

In deriving these forms from a primary, a particular rhombic pyramid P is chosen, and its dimensions determined either from the angular measurement of two of its edges, or by the linear proportion of its axes $a : b : c$; the greater lateral axis b being assumed equal to 1. To the greater lateral axis the name macrodiagonal is frequently given; to the shorter, that of brachydiagonal; and the two principal sections are in like manner named macrodiagonal and brachydiagonal, according to the axis they intersect. The same terms are applied throughout all the derived forms, where they consequently mark only the position of the faces in respect to the axes of the fundamental crystal,

without reference to the relative magnitude of the derived axes.

By multiplying the principal axis by any rational number m, greater or less than 1, a series of pyramids arise, whose general sign is mP, and their limits the prism and pinacoid, the whole series being contained in this formula, 0P - - - - - mP - - - - P - - - - mP - - - - ∞P ; which is the fundamental series, the lateral axes always remaining unchanged. From each member a new series may, however, be developed in two directions by increasing one or other of the lateral axes. When the macrodiagonal is thus multiplied by any number n greater than 1, and planes drawn from the distance n to the polar edges, a new pyramid is produced, named a macropyramid, with the sign $m\breve{P}n$, the mark over the P pointing out the axis enlarged. When $n=\infty$ a macrodome results, with the sign $m\breve{P}\infty$. If the shorter axis is multiplied, then brachypyramids and brachydomes are produced with the signs $m\bar{P}n$ and $m\bar{P}\infty$. So also from the prism ∞P, on the one side, numerous macroprisms $\infty\breve{P}n$, with the limiting ma-

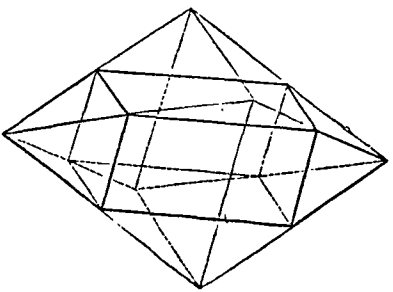


Fig. 50.

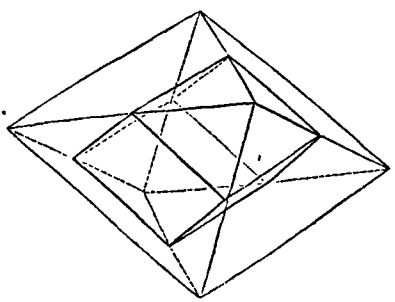


Fig. 51.

cropinacoid $\infty\breve{P}\infty$; on the other, numerous brachyprisms $\infty\breve{P}n$, with the limit form $\infty\breve{P}\infty$, or the brachypinacoid. In figs. 50, 51, the two domes are shown in their relation to the primitive pyramid.

The pyramids seldom occur independent, or even as the predominant forms in a combination,—sulphur, however, being an exception. Prisms or pinacoids usually give the general character to the crystal, which then appears either in a columnar or tabular, or even in a rectangular pyramidal form. The determination of the position of these crystals,

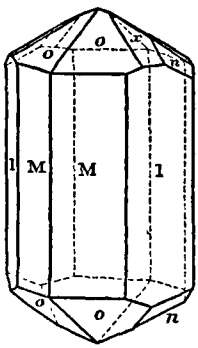


Fig. 52.

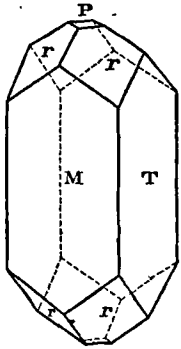


Fig. 53.

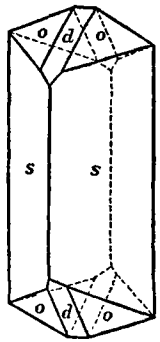


Fig. 54.

as vertical or horizontal, depends on the choice of the chief axis of the fundamental form. In the topaz crystal (fig. 52) the brachyprism and the pyramid are the predominant elements, associated with the prism, its sign and letters being $\infty\breve{P}2(l)$. P(o) . ∞P(m). Fig. 53 of stilbite is another example, the macropinacoid $\infty\bar{P}\infty$ or M, being combined with the pyramid P(r), the brachypinacoid $\infty\breve{P}\infty$ (T), and the basal pinacoid 0P (P). Another instance is fig. 54 of a lievrite crystal, where the brachyprism and pyramid combine with the macrodome, or $\infty\breve{P}2$. P . $\breve{P}\infty$. The follow-

ing figures are very common forms of barytes; figs. 55 and 56 being both composed of the pinacoid, a brachydome, and macrodome, with sign 0P (*c*). $\breve{P}\infty$ (*f*) $\frac{1}{2}\breve{P}\infty$ (*d*), the variation in aspect arising from the predominance of different faces; and fig. 57 consisting of the macrodome $\frac{1}{2}\bar{P}\infty$, the prism ∞P(*g*), and the pinacoid 0P.

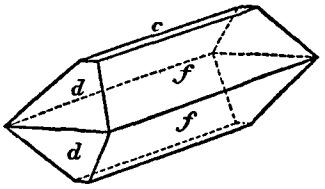


Fig. 55.

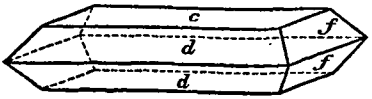


Fig. 56.

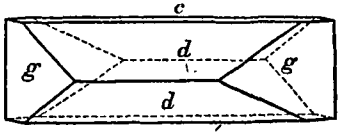


Fig. 57.

V. *The Monoclinohedric System.*—This system is characterized by three unequal axes, two of which intersect each other at an oblique angle, and are cut by the third at right angles. One of the oblique axes is chosen as the chief axis, and the other axes are then distinguished as the orthodiagonal (right-angled), and clinodiagonal (oblique-angled). The same terms are applied to the chief sections, and the name of the system refers to the fact that these two planes and the base, together with two right angles, form also one oblique angle *C*.

The forms of this system approach very near to those of the rhombic series, but the inclination of the axes, even when almost a right angle, gives them a peculiar character, by which they are always readily distinguished. Each pyramid thus separates into two altogether independent forms or hemipyramids. Three varieties of prism also occur,—vertical, inclined, and horizontal,—with faces parallel to the chief axis, the clinodiagonal or the orthodiagonal. The horizontal prisms, like the pyramids, separate into two independent partial forms, named hemiprisms or hemidomes,

The inclined prisms are often designated clinodomes, the term prism being restricted to the vertical forms. Orthopinacoids and clinopinacoids are also distinguished from their position in relation to the axes.

The monoclinohedric pyramids (fig. 58) are bounded by eight scalene triangles of two kinds, four and four only being similar. Their lateral edges lie all in one plane, and the similar triangles are placed in pairs on the clinodiagonal polar edges. The two pairs in the acute angle between the orthodiagonal and basal section are designated the positive hemipyramid; whilst the two pairs in the obtuse angles of the same sections form together the negative hemipyramid. But as these hemipyramids are wholly independent of each other, they are rarely observed combined. More frequently each occurs alone, and then forms a prism-like figure, with faces parallel to the polar edges, and open at the extremities. Hence, like all prisms, they can only appear in combination with other forms. The vertical prisms are bounded by four equal faces parallel to the principal axis, and the cross section is a rhomb; the clinodomes have a similar form and section; whilst the horizontal prisms or domes have unequal faces, and their section is a rhomboid.

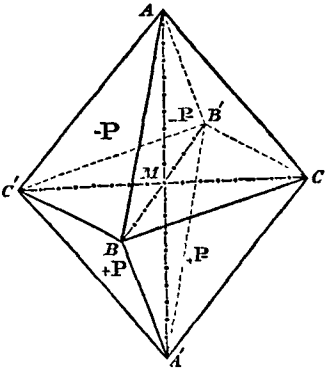


Fig. 58.

The mode of derivation of these forms closely resembles that of the rhombic series. A complete pyramid is assumed as the fundamental form, and designated $\pm$ P, in order to express the two portions of which it consists. Its dimensions are given when the proportion of its axes $a : b : c$, and the angular inclination of the oblique axes C, which is

also that of the orthodiagonal section to the basis, are known. The fundamental series of forms is 0P ..... $\pm m$P ..... $\pm$P ..... $\pm m$P ..... ∞P; from each of whose members, by changing the dimensions of the other axes, new forms may be again derived. Thus from $\pm m$P, by multiplying the orthodiagonal by any number n, a series of orthopyramids $\pm m$Pn, is produced with the orthodomes $\pm m$P∞, as limiting forms. The clinodiagonal produces a similar series, distinguished from the former by the sign being put in brackets, thus, $\pm$(mPn), with the limiting clinodome (mP∞) always completely formed, and therefore without the signs $\pm$ attached. From ∞P arise orthoprisms ∞Pn, and the orthopinacoid ∞P∞; and clinoprisms (∞Pn), and the clinopinacoid (∞P∞).

The combinations of this system may be easily understood from their resemblance to those of the rhombic; the chief difficulty being in the occurrence of partial forms, which, however, closely resemble the hemihedric forms of the previous systems. We shall therefore only select a few examples frequently observed in the mineral kingdom. Fig. 59 represents a very common form of gypsum crystals

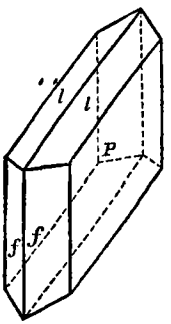


Fig. 59.

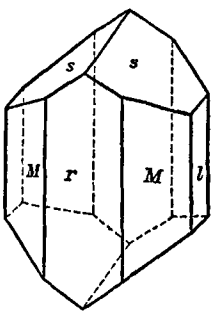


Fig. 60.

(∞P∞) (P) . ∞P(f) . P(b). The most common form of augite is represented in fig. 60, with the sign ∞P(m).

$\infty P\infty$ (r) . ($\infty P\infty$) (l) . P(s). Fig. 61 is a crystal of common felspar or orthoclase, composed of the clinopinacoid ($\infty P\infty$) (M), the prism ∞P(T), the basal pinacoid 0P (P), and the hemidomes $2P\infty$ (y): to which, in fig. 62 of

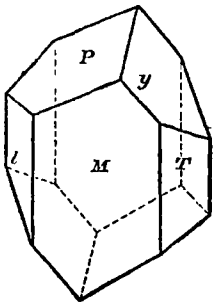


Fig. 61.

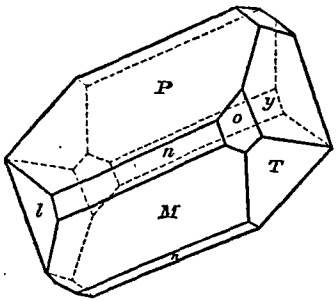


Fig. 62.

the same mineral, the hemipyramid P(o), and the clinodome ($2P\infty$) (n), are added.

VI. *Triclinohedric System.*—This is the least regular of all the systems, and departs the most widely from symmetry of form. The axes are all unequal, and inclined at angles none of which are right angles, so that to determine any crystal or series of forms the proportion of the axes $a : b : c$, and also their angles, or those of the inclination of the chief sections, must be known. As in the previous system, one axis is chosen as the principal axis, and the two others distinguished as the macrodiagonal and brachydiagonal axes. In consequence of the oblique position of the principal sections, this system consists entirely of partial forms wholly independent on each other, and each composed only of two parallel faces. The complete pyramid is thus broken up into four distinct quarter pyramids, and the prism into two hemiprisms. Each of these partial forms is thus nothing more than a pair of parallel planes, and the various forms consequently mere individual faces. This circumstance renders many triclinohedric crystals very unsymmetrical in appearance.

Triclinohedric pyramids (fig. 63) are bounded by eight triangles, whose lateral edges lie in one plane. They are equal and parallel two and two to each other; each pair forming, as just stated, a tetartopyramid or open form, only limited by combination with other forms, or, as we may suppose, by the chief sections. The prisms are again either vertical or inclined; the latter named domes, and their section is always rhomboidal. In deriving the forms, the fundamental pyramid is placed upright with its brachydiagonal axis to the spectator, and the partial forms designated, the two upper by 'P and P', the two lower by ,P and P,, as in the figure. The further derivation now follows as in the rhombic system, with the modifications already mentioned, so that we need not delay on it longer, especially as the minerals crystallizing in these forms are not numerous.

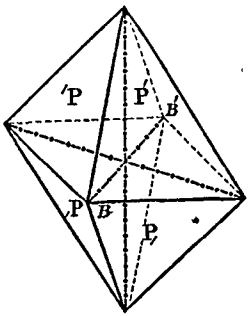


Fig. 63.

Some combinations of this system, as the series exhibited by most of the felspars, approach very near to the mono-

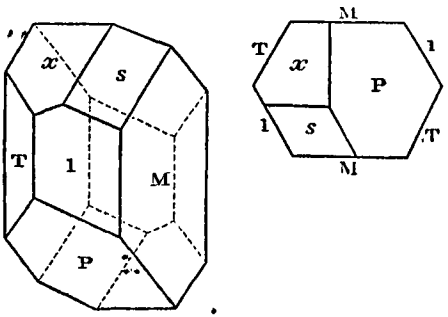


Fig. 64.

clinohedric system; whilst others, as the blue copper, or vitriol, and axinite, show great incompleteness and want of

symmetry. In the latter case the determination of the forms is often difficult and requires great attention. As specimens, we may notice the albite crystal (fig. 64), in which *P* is the basal pinacoid 0P; *M* the brachydiagonal pinacoid $\infty\breve{P}\infty$; *s* the upper right pyramid P'; *l* the right hemiprism ∞P'; *T* the left hemiprism ∞'P; and *x* the hemidome '$\bar{P}'\infty$. Figures 65 and 66 are crystals of axinite, the

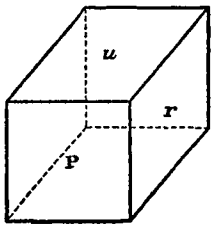


Fig. 65.

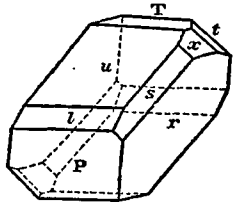


Fig. 66.

former from Dauphiné, the latter very common in Cornwall, of whose faces the following is the development:—*r* the macropinacoid $\infty\bar{P}\infty$; *P* the left hemiprism ∞'P; *u* the left upper quarter pyramid 'P; *l* the left upper quarter pyramid 2'P; *s* the left upper partial form of the macropyramid $3'\bar{P}3$; and *x* the hemidome $2'P_{,}\infty$.

Imperfections of Crystals.

In the foregoing description of the forms of crystals the planes have been supposed smooth and even, the faces equal and uniform, or at the same distance from the centre or point of intersection of the axes, and each crystal also perfect or fully formed and complete on every side. In nature, however, these conditions are rarely if ever realized, and the edges of crystals are seldom straight lines, or the faces mathematical plane surfaces. A very interesting variety of these irregularities, which pervades all the systems except the tesseral, is named *hemimorphism*. In this the crystals are bounded on the opposite ends of their chief

axis by faces belonging to distinct forms, and hence only the upper or under half of each form is produced, or the crystal, as the name implies, is half-formed. Figure 67 represents a common variety of tourmaline, bounded on the

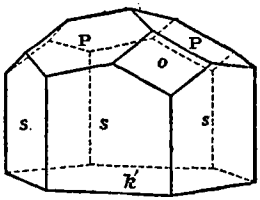


Fig. 67.

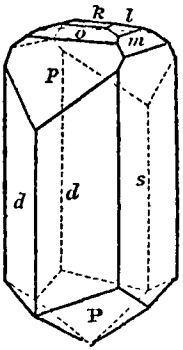


Fig. 68.

upper end by the planes of the rhombohedrons R and $-2R$, and on the lower end by the basal pinacoid. In fig. 68 of electric calamine the upper extremity shows the basis *k*, two brachydomes *o* and *p*, and two macrodomes *m* and *l*; whilst on the lower end it is bounded by the faces P of the primary form. This appearance becomes more interesting from the fact, that most hemimorphic crystals acquire polar electricity from heat,—that is, exhibit opposite kinds of electricity at opposite ends of the crystal.

The faces of crystals are very frequently rendered imperfect by *striæ* or minute linear and parallel elevations and depressions. These arise in the oscillatory combination of two crystal forms, alternately prevailing through small spaces. The striæ, therefore, are in reality the edges of combined forms. They are very common on quartz, shorl, and some other minerals; and frequently indicate combinations where only a simple form would otherwise appear to exist. The cubes and pentagonal dodecahedrons of iron pyrites are frequently striated, and in three directions at

right angles to each other. In calc-spar the faces of the rhombohedron, $-\frac{1}{2}R$ (*g* in fig. 43 above) are almost never without striæ parallel to the oblique diagonal. The striation is said to be simple when only one series of parallel lines appears on each face, or feathered when two systems diverge from a common line. In other crystals the faces, then said to be *drusy*, are covered by numerous projecting angles of smaller crystals; an imperfection often seen in fluor spar. The faces of crystals occasionally appear curved either, as in tourmaline and beryl, from the peculiar oscillatory combination mentioned, or by the union of several crystals at obtuse angles, like stones in a vault, as in stilbite and prehnite. A true curvature of the faces probably occurs in the saddle-shaped rhombohedrons of brown spar and siderite, in the lens-like crystals of gypsum, and in the curved faces so common on diamond crystals. In chabasite similar curved faces occur, but concave. In galena and augite the crystals are often rounded on the corners as if by an incipient state of fusion. On other crystals the faces are rendered uneven from inequalities following no certain rule. These imperfections furnish valuable assistance in developing very complex combinations, all the faces of each individual form being distinguished by the same peculiarity of surface.

Irregularities in the forms of crystals are produced when the corresponding faces are placed at unequal distances from the centre, and consequently differ in form and size. Thus the cubes and octahedrons of iron pyrites, galena, and fluor spar, are often lengthened along one axis. Quartz is subject to many such irregularities, which are seen in a very remarkable manner on the beautiful transparent and sharply angular crystals from Dauphiné. In such irregular forms, instead of one line, the axes are then represented by an infinite number of lines, parallel to the ideal axis of the figure. The same irregularity carried to a greater extent frequently causes certain faces required for the symmetry

of the form, altogether to disappear. Again, some crystals do not fill the space marked out by their outline, holes and vacancies being left in the faces, occasionally to such an extent that they seem little more than mere skeletons. This appearance is very common on crystals produced artificially, as in common salt, alum, bismuth, silver, &c. A perfect crystal can only be produced when, during its formation, it is completely isolated, so as to have full room to expand on every side. Hence the most perfect crystals have been originally imbedded singly in some uniform rock mass. Next to them in perfection are forms that grow singly on the surface of some mass of similar or distinct composition, especially when the point of adherence is small. An incompleteness of form, or at least a difficulty in determining it, arises from the minuteness of some crystals, or from their contracted dimensions in certain directions. Thus some appear mere tabular, or lamellar planes, whilst others run out into acicular, needle-shaped, or capillary crystals. Amid all these modifications of the general form of the crystal, of the condition and aspect of its individual faces, or of its linear dimensions, one important element, the angular measurement, remains constant. In some monoaxial crystals, indeed, increase of temperature produces an unequal expansion in different directions, slightly changing the relative inclination of the faces, but so small as to be scarcely perceptible in common measurements, and hence producing no ambiguity. More important are the angular changes which in many species accompany slight changes in chemical composition, particularly in the relative proportions of certain isomorphous elements. But notwithstanding these limitations, the great truth of the permanence of the angular dimensions of crystals, announced by Romé de l'Isle, remains unaffected; only, as Mohs well states, it must not be interpreted with a rigid immutability, inconsistent with the whole analogy of other parts of nature.

The Goniometer and Measurement of Crystals.

The fact just stated of the permanence of the angular dimensions of crystals shows the importance of some accurate method of measuring their angles; that is, the inclination of two faces to each other. Two instruments have been specially used for this purpose,—the common or contact goniometer, invented by Caringeau, and the reflecting goniometer of Wollaston. The former is simply two brass rulers turning on a common centre, between which the crystal is so placed that its faces coincide with the edges of the rulers, and the angle is then measured on a graduated arc. This instrument is sufficiently accurate for many purposes and for large crystals; but for precise determination is far inferior to the reflecting goniometer. This requires smooth and even faces, but these may be very small, even the hundredth of an inch, in skilful hands; and as small crystals are generally most perfect, far greater accuracy can be attained, and the measurement depended on to one minute (1′).

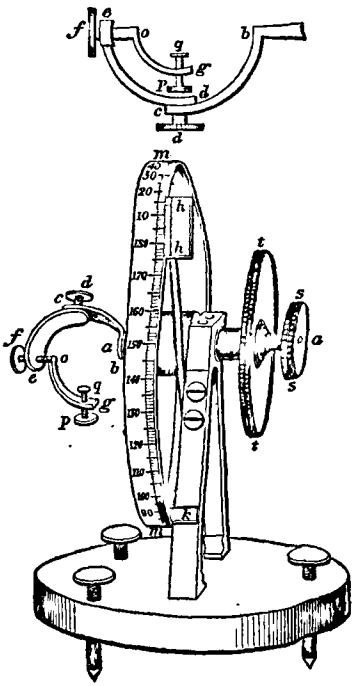


Fig. 69.

The reflecting goniometer is represented in the annexed figure. It consists essentially of a graduated circle *mm*, divided on its edge into twice 180°, or more often into half degrees, the

minutes being read off by the vernier *hh*. This circle turns on an axis connected with *tt*, so that by turning this the circle is moved round, but is stopped at 180°, when moving in one direction, by a spring at *k*. The other part of the instrument is intended to attach and adjust the crystal to be measured. The first axis of *mm* is hollow, and a second axis, *aa*, passes through it from *ss*, so that this and all the connected parts from *b* to *f* can be turned without moving the circle *mm*. The axis *d* passes through a hole in *bc*, so that it can turn the arm *de* into any required position; *f* is a similar axis turning the arm *og*; and *pq* a fourth axis, in like manner moveable in *g*, and with a small knob at *q*, to which the crystal to be measured is attached.

When about to use the instrument it should be placed on a table, with its base horizontal, which is readily done by the screws in it, and opposite to a window at about 12 or 15 feet distance, so that its axis shall be parallel to the horizontal bars of the window. One of the upper bars of the window, and also the lower bar, or, instead of the latter, a white line on the floor or table parallel to the window, should then be chosen in order to adjust the crystal. The observer places himself behind the instrument with the side *a* at his right hand. The crystal is then attached to *q* by a piece of wax with the two faces to be measured upwards. The axis *fo* is made parallel to *aa*, and the eye being brought near to the first face of the crystal, the axes *aa* and *p* are turned till the image of the window is seen reflected in the face with the horizontal and vertical bars in their position. The axis *d* is then turned through a considerable angle (say 60°), and the image of the window again sought and brought into its proper place by turning the axis *f*, without moving *p*. When this is done that face is brought into its true position, normal to *d*, so that no motion of *d* can disarrange it. Hence the image of the window may now be sought in the second face and brought into its true position, with the horizontal bars seen horizontal, by

moving the axes *d* and *a*. When this is done the crystal is properly adjusted, and the angle is thus measured. First bring the zero of the circle and vernier to coincide, and then turn the inner axis *a* or *ss*, and move the eye till the image of the upper bar of the window reflected from the more distant face of the crystal coincides with the lower bar or horizontal line seen directly. Keeping the eye in its place, turn the outer axis *tt* till the reflected image of the upper bar in the other face in like manner coincides with the lower line, and the angle of the two faces is then read off on the divided circle. As the angle measured is not directly that of the faces, but of the rays of light reflected from them, or the difference of the angle wanted from 180°, the circle has the degrees numbered in the reverse direction, so as to give the angle without the trouble of subtracting the one from the other.

The above apparatus for adjusting the crystal is an improvement suggested by Naumann. In the original instrument the axis *fo* was made to push in or out in a sheath, and had a small brass plate, bent at right angles, inserted in a cleft at *o*, to which the crystal was attached. The crystal was adjusted, as formerly, by moving the plate, or the axis *fo*, and by slight motion of the arm *de*, which should be at right angles nearly to *bc* when used. A considerable improvement is, to have a small mirror fixed on the stand below the crystal, with its face parallel to the axis *aa*, and inclined at 45° to the window, when the lower line can be dispensed with, and the instrument used for various other purposes of angular measurement. Many alterations have been suggested for the purpose of insuring greater accuracy; but the simple instrument is sufficient for all purposes of determinative mineralogy, and the error from the instrument will in most cases be less than the actual variations in the dimensions of the crystals. Greater simplicity is indeed rather desirable, and the student will often find it sufficient to attach the crystal by a piece of wax to the axis *a* directly,

and give it the further adjustment by the hand. The only use of the parts from *b* to *q* is to enable the observer to place the crystal properly; that is, with the edge to be measured parallel to the axis of the instrument, and as nearly as possible coinciding with its centre. This is effected when the reflection of the horizontal bar in the two faces appears parallel to that edge.

Macles or Twin Crystals.

When two similar crystals of a mineral species are united with their similar faces and axes parallel, the one forms merely a continuation or enlargement of the other, and every crystal may be regarded as thus built up of a number of smaller crystals. Frequently, however, crystals are united according to precise laws, though all their similar faces and axes are not parallel, and then are named macles or twin crystals. In one class of macles the axes of the two crystals are parallel, and in another they are inclined. The former only occur among hemihedric forms, and the two crystals are then combined in the exact position in which they would be derived from or reproduce the primary holohedric form. The second class, with oblique axes, occur both in holohedric and hemihedric forms, and the two individuals are placed in perfect symmetry to each other, in reference to a particular face of the crystal which forms the plane of union, or the equator of the macle. We may also suppose the two crystals originally parallel, and the one turned round the normal of the united faces by 180° (often 90° or 60°), whilst the other is stationary. Or we may suppose a crystal cut into halves in a particular direction, and one-half turned 180° on the other; and hence the name of hemitrope given to them by Hauy. The position of the two individuals in this case corresponds with that of an object and its image in a mirror, whose surface then represents the plane of union.

The manner in which the crystals unite also differs. Some are merely opposed or in simple contact; others are, as it were, grown together, and mutually interpenetrate, occasionally so completely as to appear like one individual, The twin edges and angles in which the two unite are often re-entering; or they may coincide in one plane, when the line of union is either imperceptible, or is only marked by the meeting of two systems of striæ, or other diversity in the physical characters of the two faces.

The formation of twin crystals may be again repeated, forming groups of three, four, or more. When the faces of union are parallel to each other, the crystals form rows of indeterminate extent; where they are not parallel, they may return into each other in circles, or form bouquet-like or other groups. Where crystals are merely in juxtaposition, they are sometimes much shortened in the direction of the twin axis; and where many occur in a series with parallel position, are often compressed into very thin plates, frequently not thicker than paper, giving to the surface of the aggregate a peculiar striated aspect.

Only a few twin crystals in the different systems can be noticed, chiefly as examples of this mode of formation. In the tesseral system forms that unite with parallel axes produce intersecting macles like the pentagonal dodecahedrons

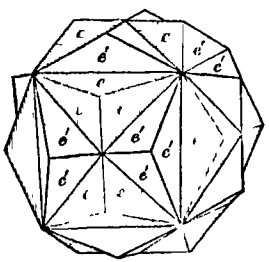


Fig. 70.

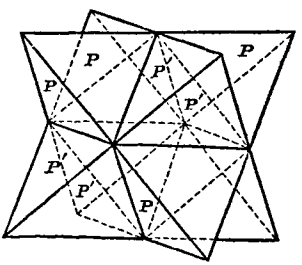


Fig. 71.

of iron pyrites in fig. 70, and the tetrahedrons of grey-copper or fahlore in fig. 71, a similar formation also occurring

in the diamond. In macles with inclined axes the two forms almost always unite by a face of the octahedron, and the two individuals are then generally apposed and shortened in the direction of the twin axis by one-half, so that they appear like a crystal that has been divided by a plane parallel to one of its faces, and the two halves turned round on each other by an angle of 180°. In this manner two octahedrons of the spinel, magnetic iron ore, or automolite (fig. 72), are

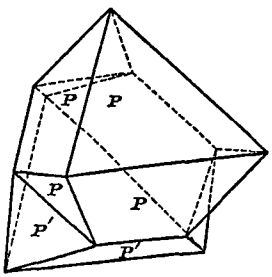


Fig. 72.

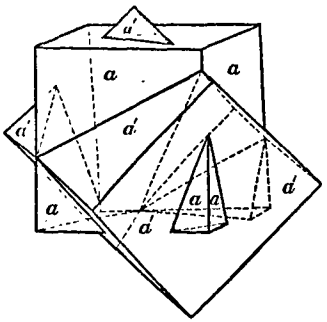


Fig. 73.

frequently united. The same law prevails in the intersecting cubes of fluor spar, iron pyrites, and galena, represented in fig. 73. In fig. 74 of zinc-blende two rhombic dodecahedrons are united by a face of the octahedron.

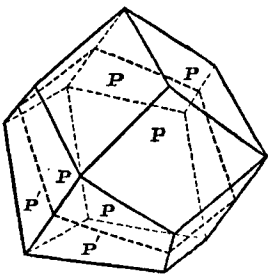


Fig. 74.

In the Tetragonal system twin crystals with parallel axes rarely occur, but are seen in chalcopyrite, and one or two other minerals. Where the axes are inclined the plane of union is very often one of the faces of the pyramid $P\infty$, or one of those faces that would regularly replace the polar edges of the fundamental form P. The crystals of tin ore obey this law, as seen in

fig. 75, where the individuals are pyramidal, and in the knee-shaped crystal (fig. 76), where they are more pris-

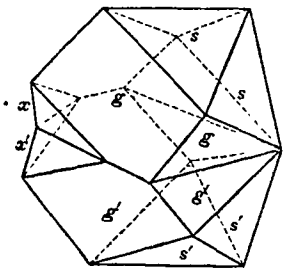


Fig. 75.

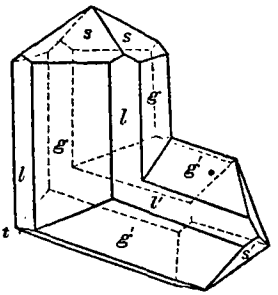


Fig. 76.

matic. Hausmanite appears like fig. 77, in which the fundamental pyramid P prevails, on whose polar edges other crystals are often very symmetrically repeated, a central individual appearing like the support of all the others. Almost identical forms occur in chalcopyrite.

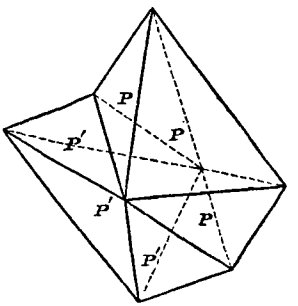


Fig. 77.

In the Hexagonal system twin crystals with parallel axes are common, as in calc-spar, chabasite, hæmatite, and other rhombohedric minerals. In calc-spar they often form very regular crystals, the two individuals uniting by a plane parallel to the base, so as to appear like a single crystal, as in fig. 78, where each end shows the forms $\infty R.-\frac{1}{2}R$, but in a complementary position; or in fig. 79 of two scalenohedrons R^3 from Derbyshire. The rhombohedric crystals of chabasite often appear intersecting each other, like those of fluor spar in fig. 73. The purer varieties of quartz or rock-crystal, in consequence of the tetartohedric character of its crystallization, often ex-

hibit twins. In these the pyramid P separates into two rhombohedrons P and z, which though geometrically similar, are yet physically distinct. In fig. 80 the two indivi-

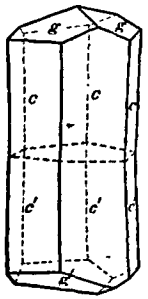


Fig. 78.

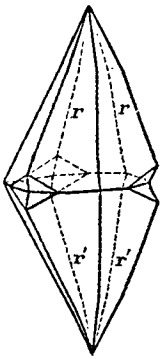


Fig. 79.

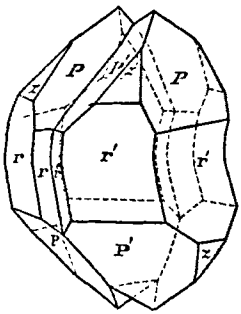


Fig. 80.

duals are only grown together, but more commonly they penetrate each other in an irregular manner, forming apparently a single crystal. Twins with oblique axes are also common, the plane of union being usually one face of the rhombohedron. Thus in calc-spar two rhombohedrons are often joined by a face of $-\frac{1}{2}$R, the two axes forming an angle of 127° 34′; occasionally a third individual is interposed in a lamellar form, as in fig. 81, when the two

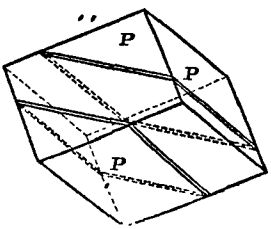


Fig. 81.

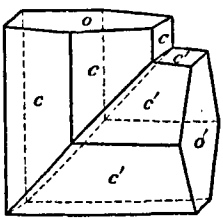


Fig. 82.

outer crystals become parallel. This latter arrangement is very common in the highly cleavable varieties of Iceland spar. When the crystals unite in a face of the rhombohedron R, fig. 82, they form an angle of 89° 8′, differing

little from a right angle, by which the occurrence of this law is very easily recognised, especially in prismatic varieties.

In the rhombic system twin crystals with parallel axes are very rare, but those with oblique axes common, the plane of union being one of the faces of the prism ∞P. Twins of this kind are very distinctly seen in arragonite, carbonate of lead, marcasite, stephanite, mispickel, and other minerals. In arragonite the crystals partly interpenetrate, partly are in mere juxtaposition, as in fig. 83, where the individuals are formed by the combination $\infty P(M)$. $\infty \breve{P}\infty (h)$, $\breve{P}\infty (k)$, and in figure 84 where several crystals of the same combination form a series with parallel planes of union; the inner members being so shortened that they appear like mere lamellar plates producing striæ on the faces $\breve{P}\infty$ and $\infty\breve{P}\infty$ of the macle. In fig. 85 four crys-

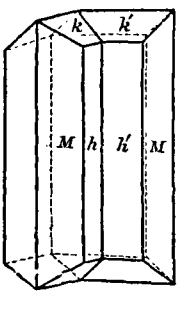


Fig. 83.

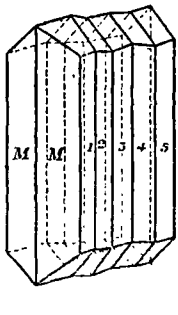


Fig. 84.

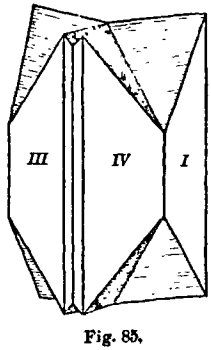


Fig. 85.

tals, each of the combination ∞P . $2\breve{P}\infty$, having united in inclined planes, form a circular group, returning into itself. The carbonate of lead often occurs in macles in all respects similar. In staurolite, individuals of the prismatic combination ∞P . $\infty\breve{P}\infty$. $0P$, combine either, as in fig. 86, by a face of the brachydome $\frac{3}{2}\breve{P}\infty$, with their chief axes almost at right angles; or, as in fig 87, by a face of the brachypyramid $\frac{3}{2}\breve{P}\frac{3}{2}$, the chief axes and the brachypinacoids (o) of

the two single crystals meeting at an angle of about 60°.

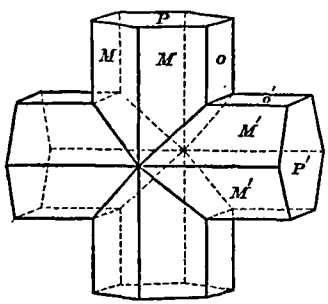


Fig. 86.

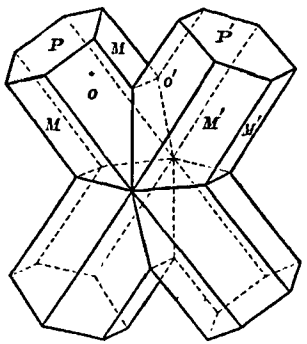


Fig. 87.

Finally, in fig. 88 two harmotome crystals of the most common combination $\infty\breve{P}\infty$. $\infty\breve{P}\infty$. P . $\breve{P}\infty$, intersect each other so nearly at right angles, that their principal axes seem to coincide, and the brachypinacoid (*q*) of the one crystal (with rhombic striæ) is parallel to the macropinacoid (*o*) of the other.

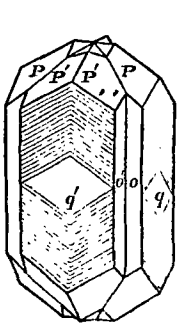


Fig. 88.

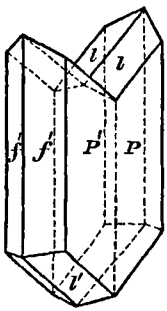


Fig. 89.

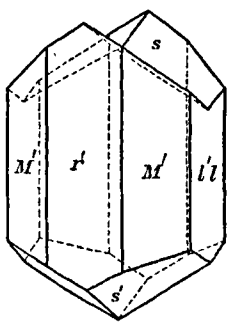


Fig. 90.

In the monoclinohedric system the most common macles are those in which the principal axes and the chief sections of the two crystals are parallel to each other, and consequently the principal axis is also the twin axis. Usually

the two individuals are united by a face parallel to the orthodiagonal chief section, as in figure 89 of gypsum, where two crystals of the combination $(\infty P\infty) . \infty P . -P$, shown in fig. 59, unite so regularly that the faces of the pinacoids (*P* and *P'*) form only one plane. In a similar manner the augite crystals of the combination $\infty P . \infty P\infty . (\infty P\infty) . P$, represented singly in fig. 60, are in fig. 90 united in a macle so very symmetrical and regular that the line of junction cannot be observed on the face of the clinopinacoid. The two hemipyramids P (*s*) (like $-P$ (*l*) in the gypsum crystal above) form on one side a re-entering, on the other a salient angle. Hornblende, wolfram, and other minerals exhibit a similar appearance. In other cases the individuals partially penetrate each other, being, as it were, crushed together in the direction of the orthodiagonal. This mode of union is not uncommon in gypsum, and very frequent in orthoclase felspar. Two crystals of the latter, of the combination $(\infty P\infty) . \infty P . 0P . 2P\infty$, as in fig. 61 above, are often pushed sidewise into each other as shown in fig. 91.

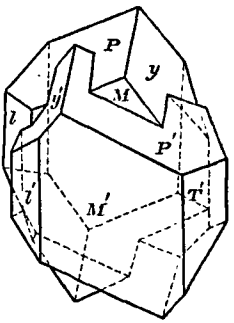


Fig. 91.

In the triclinohedric system some twin formations are of great importance as a means of distinguishing the triclinohedric from the monoclinohedric species of felspar. In one variety the twin axis is the normal to the brachydiagonal chief section. But in the triclinohedric felspars this section is not, as it is in the monoclinohedric species, perpendicular to the basis, and consequently the two bases form on one side a re-entering, on the other a salient angle; whereas in the monoclinohedric felspars (where the brachydiagonal chief section corresponds to the clinodiagonal), no twin crystals can be produced in conformity to this law, and

the two bases fall in one plane. The albite and oligoclase very often exhibit such twins, as in figure 92, where the very

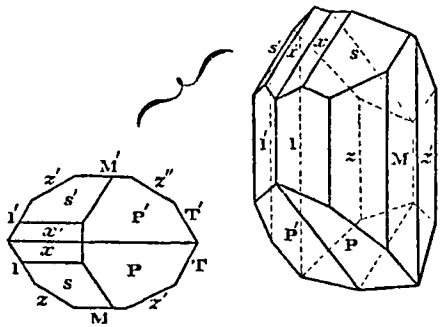


Fig. 92.

obtuse angles formed by the faces of 0P, or P and P' (as well as those of $\bar{P}'\infty$, or x and x') are a very characteristic appearance, marking out this mineral at once as a triclinohedric species. Usually the twin formation is repeated, three or more crystals being combined, when those in the centre are reduced to mere plates. When very numerous, the surfaces P and x are covered with fine striæ, often only perceptible with a microscope. A second law observed in triclinohedric felspars, particularly the albite and labradorite, is that the twin axis corresponds with that normal of the brachydiagonal which is situated in the plane of the base. In pericline, a variety of albite, these twins appear as in fig. 93, where the two crystals are united by a face of the basal pinacoid P, whilst the faces of the two brachypinacoids (M and M') form edges with very obtuse angles (173° 22′), re-entering on the one side and salient on the other. These edges, or the line of junction between M and M', are also parallel to the edges formed by these faces and the

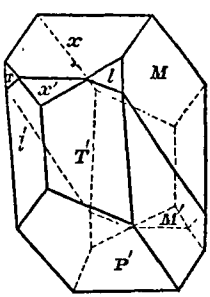


Fig. 93.

base, or those between *M* and *P*. In this case also the macles are occasionally several times repeated when the faces appear covered with fine striæ.

Irregular Aggregation of Crystals.

Besides the regular unions now described crystals are often aggregated in peculiar ways, to which no fixed law can be assigned. Thus some crystals, apparently simple, are composed of concentric crusts or shells, which may be removed one after the other, always leaving a smaller crystal like a kernel, with smooth distinct faces. Some specimens of quartz from Beeralston in Devonshire consist apparently of hollow hexagonal pyramids placed one within another. Other minerals, as fluor spar, apatite, heavy spar, and calc-spar, exhibited a similar structure by bands of different colours.

Many large crystals, again, appear like an aggregate of numerous small crystals, partly of the same, partly of different forms. Thus some octahedrons of fluor spar from Schlaggenwald are made up of small dark violet-blue cubes, whose projecting angles give a drusy character to the faces of the larger form. Such polysynthetic crystals, as they may be called, are very common in calc-spar.

A similar, but still more remarkable formation, is where two crystals of distinct species are conjoined. Such unions of cyanite and staurolite have been long well known, and the graphic-granite exhibits a similar union between large felspar crystals and many smaller ones of mica and quartz.

Forms of Crystalline Aggregates.—Crystals have often been produced under conditions preventing the free development of their forms. They then compose crystalline aggregates, of which the following may be distinguished :— *Granular*, formed of grains, generally angular, but rarely rounded or flattened. *Lamellar* consist of broad plates, which are *tabular* when of uniform thickness, *lenticular*

when becoming thinner on the edges, *wedge-shaped* when sharpened towards one edge, and *scaly* when the plates are very small. *Columnar*, in which the individuals are drawn out in one direction more than in the others; *bacillary* or rod-like, in which the columns are of uniform thickness; *acicular* or needle-shaped, in which they are pointed; and *fibrous*, in which they are very fine. In the broad-columnar the columns are, as it were, compressed, or broader in one direction than the other. The distinctions of large, coarse, small, or fine-granular; thick or thin scaly; straight, curved, or twisted-columnar; parallel, diverging, or confused-fibrous; and such like, are easily understood.

Aggregates which have been able to crystallize, at least, with a certain degree of freedom, have been distinguished by Mohs into crystal groups and druses; the former including all unions of several imbedded crystals; the latter those of crystals that have grown together on a common support. In the groups crystals with their faces otherwise perfect are conjoined in various ways. Sometimes they radiate, as it were, from a common centre, and produce spheroidal, ellipsoidal, or other forms, frequent in gypsum, iron pyrites, and other minerals imbedded in clay. Where many such masses are united, they are named *botryoidal* when like bunches of grapes, *mammellated* where the spheres are larger and less distinct, and *reniform* or kidney-shaped where the masses are still larger. Some groups are partially attached by a small point; but the mass is generally free.

Crystals are often grouped in rows or in one direction, forming, when they are very small, capillary or hair-like, and filiform, thread, or wire-like forms, which are common among native metals, as gold, silver, copper, and bismuth, in silver glance and a few other minerals. Sometimes the masses are dentiform, consisting of portions resembling teeth; as is very common in silver. Often these groups expand in several directions, and produce arborescent,

dendritic, foliated, feathered, or other forms, very common in copper. In these groups, however, a certain dependence on the crystallographic character of the species may be observed. The lamellar minerals often form fan-shaped, wheel-like, almond-shaped, comb-like, or other groups. The fibrous types, again, are disposed in parallel or diverging bundles, or in radiating, stellar, and other masses. Coralloidal (like coral), fruticose (like cauliflower), and other forms, have also been observed.

In druses, many crystals rise side by side from a common support; sometimes only the granular mass composed of their united bases, at other times some distinct body. The form of a druse is determined by that of the surface on which it grows, and consequently is often very irregular or wholly accidental. Where completely inclosed they have been named drusy cavities, and when of a spheroidal form, geodes. A drusy crust, again, consists of a thin layer of small crystals investing the surface of a large crystal or of some other body.

The minute or cryptocrystalline minerals form similar aggregates. In the globular or the oolitic the minute crystals often appear to radiate from a centre, or form concentric crusts. Somewhat similar are the stalactites and stalagmites, in which the mineral, especially rock-salt, limestone, chalcedony, opal, limonite, has been deposited from a fluid dropping slowly from some overhanging body. In this case the principal axis of the figure, generally a hollow tube, is vertical, whilst the individual parts are arranged at right angles to this direction. In other cases the mineral has apparently been deposited from a fluid mass moving slowly in a particular direction, which may be regarded as the chief axis of the figure, whilst the axes of the individual crystals may assume a different position.

By far the largest masses of the mineral kingdom have, however, been produced under conditions in which a free development of their forms was excluded. This has been

the case with the greater portion of the minerals composing rocks or filling veins and dykes. The structure of these masses on the large scale belongs to geology, but some varieties of the texture visible even in hand specimens may be noticed. The individual grains or masses have seldom any regular form, but appear round, long, or flat, according to circumstances, and as each has been more or less checked in the process of formation. Even then, however, a certain regularity in the position of the parts is often observable, as in granite, in which the cleavage planes, and consequently the axes of the felspar crystals, are parallel. Where these grains are all pretty similar in size and shape, the rock is named massive when they are small, or granular when they are larger and more distinct. Sometimes the rock becomes slaty, dividing into thin plates; or concretionary, forming roundish masses; at other times the interposition of some foreign substance (gas or vapour) has rendered it porous, cellular or vesicular, giving rise to drusy cavities. These cavities are often empty, but have occasionally been filled by other minerals, when the rock is named amygdaloidal, from the almond-like shape of the inclosed masses.

Many of the above external forms appear also in the amorphous solid minerals, in which no trace of individual parts, and consequently of internal structure, is observable. They are not unfrequently disposed in parallel or concentric layers, of uniform or distinct colours; and may assume spherical, cylindrical, stalactitic, and other appearances.

Pseudomorphism.—When the substance of one mineral assumes the external form of some other mineral it is named a pseudomorph. In some named incrusting pseudomorphs the original crystal is covered by a rough or drusy surface of the second mineral, frequently not thicker than paper. Occasionally the first crystal has been removed, and nothing but the shell remains; or the cavity has been filled by a distinct mineral species, or a crystalloid, as it may be

named, forming an exact representation of the original, but of a different substance.

More commonly the new mineral substance has gradually expelled the old, and replacing it, as it were, atom by atom, has assumed its exact form. In other cases not the whole substance of the original crystal, but only one or more of its elements, has been changed, or the whole matter has remained, but in a new condition. Thus arragonite crystals have been converted into calc-spar, the chemical composition of both being identical; or gaylussite has been changed into calc-spar, andalusite into cyanite, by the loss of certain elements. On the other hand, anhydrite becomes gypsum, red-copper ore malachite, by addition of new matter. Or the elements are partially changed, as felspar into kaolin, quartz or pearl spar into talc, iron pyrites or iron glance into brown-iron ore, azurite into malachite, augite into green earth. The true nature of such bodies is shown by the internal structure, having no relation to the external form or apparent system of crystallization.

The process of petrifaction of organic bodies is in reality a species of pseudomorphic formation, and has been produced in all the above modes. External and internal casts of organic bodies are not uncommon. In other cases the original substance has been replaced by some mineral which has preserved not merely the external form, but even the minutest detail of internal structure; so that the different kinds of wood have been distinguished in their silicified trunks. The most common petrifying substances are silica and carbonate of lime. In encrynites, echinites, belemnites, and other fossils, the crystals of calc-spar often occur in very regular positions. In some varieties of petrified wood both the ligneous structure and the cleavage of the calc-spar are observable.

Different from the above are mineralized bodies, in which the original structure is still retained, but their chemical nature partially changed. In these a complete series may

be often traced, as from wood or peat, through the varieties of brown coal, common coal, anthracite, and graphite, perhaps even to the diamond.

CHAPTER II.

PHYSICAL PROPERTIES OF MINERALS.

The physical characters of minerals comprehend,—1*st.* Those properties derived from the nature of the substance itself, as coherence, mode of fracture, elasticity, and density or specific gravity; 2*d.* Those phenomena called forth in minerals by the influence of some external power or agent, as their optical, electric, or thermal relations; and, 3*d.* Other characters depending on the personal sensation of the observer—on his taste, smell, and touch. All these properties furnish useful characters in distinguishing and describing mineral species.

Cleavage and Fracture.

In many species there are certain planes at right angles to which cohesion seems to be at a minimum, so that the mineral separates along or parallel to these planes far more readily than in any other direction. This property is named cleavage, and these planes cleavage-planes. They have a strictly definite position, and do not show any transition or gradual passage into the greater coherence in other directions. The number of these parallel cleavage-planes is altogether indefinite; so that the only limit that can be assigned to the divisibility of some minerals, as gypsum and mica, arises from the coarseness of our instruments.

These minima of coherence or cleavage-planes are always parallel to some face of the crystal, and similar equal

minima occur parallel to every other face of the same form. Hence they are always equal in number to the faces of the form, and the figures produced by cleavage agree in every point with true crystals, except that they are artificial. They are thus most simply and conveniently described by the same terms and signs as the faces of crystals. Some minerals cleave in several directions parallel to the faces of different forms, but the cleavage is generally more easily obtained and more perfect in one direction than in the others. This complex cleavage is well seen in calc-spar, and fluor spar, and very remarkably in zinc-blende, where it takes place in no less than six directions. As in each of these the division may be indefinitely continued, it is clear that no lamellar structure in any proper sense can be assigned to the mineral. All that can be affirmed is, that contiguous atoms have less coherence in the normal of these planes than in other directions. When the cleavage takes place in three directions, it of course produces a perfect crystal form, from which the system of crystallization and angular dimensions of the species may be discovered, and is thus often of very great importance.

The common cleavage in the different systems is as follows, those of most frequent occurrence being put in italics: —(1.) In the tesseral, *Octahedric*, O, along the faces of the octahedron; *Hexahedric*, $\infty O \infty$, along those of the cube; and Dodecahedric, ∞O. (2.) In the tetragonal system, Pyramidal, P or $2P\infty$; *Prismatic*, ∞P or $\infty P\infty$; or *Basal*, 0P. (3.) In the hexagonal system with holohedric forms, Pyramidal, P or P2; *Prismatic*, ∞P or $\infty P2$; or *Basal*, 0P; with rhombohedral forms, *Rhombohedric*, R; Prismatic, ∞R; or *Basal*, 0R. (4.) In the rhombic system, Pyramidal, P; *Prismatic*, ∞P; Makro or Brachydomatic, $\breve{P}\infty$ or $\breve{P}\infty$; *Basal*, 0P; Macrodiagonal, $\infty\breve{P}\infty$; or *Brachydiagonal*, $\infty\breve{P}\infty$. (5.) In the monoclinohedric system, Hemipyramidal, P or $-P$; *Prismatic*, ∞P; Clinodomatic, $(P\infty)$; Hemidomatic, $P\infty$ or $-P\infty$; *Basal*, 0P;

Orthodiagonal, $\infty P\infty$; or *Clinodiagonal*, ($\infty P\infty$). (6.) In the triclinohedric system, Hemiprismatic, $\infty P'$ or $\infty'P$; Hemidomatic either along the macrodome or brachydome ; *Basal*, 0P ; Macrodiagonal, $\infty\breve{P}\infty$; or *Brachydiagonal*, $\infty\breve{P}\infty$.

In some minerals the cleavage is readily procured ; in others only with extreme difficulty. The planes produced also vary much in their degree of perfection, being *highly* perfect in some, as mica and gypsum ; imperfect in others, as garnet and quartz. In a very few crystalline minerals cleavage-planes can hardly be said to exist. Cleavage must be carefully distinguished from the planes of union in twin crystals, and the division-planes in the laminar minerals.

Fracture surfaces are formed when a mineral breaks in a direction different from the cleavage-planes. They are consequently most readily observed when the cleavage is least perfect. The form of the fracture is named *conchoidal* when composed of concave and convex surfaces like shells, *even* when nearly free from inequalities. The character of the surface is *smooth ;* or *splintery* when covered by small wedge-shaped splinters adhering by the thicker end ; or *hackly* when covered by small slightly-bent inequalities, as in iron and other malleable bodies ; or *earthy* when it shows only fine dust.

Hardness and Tenacity.

The hardness of minerals, or their power of resisting any attempt to separate their parts, is also an important character. As it differs considerably in the same species, according to the direction and the surface on which the trial is made, its accurate determination is difficult, and the utmost that can usually be obtained is a mere approximation found by comparing different minerals one with another. For this purpose Mohs has given the following scale :—

1. *Talc*, of a white or greenish colour.
2. *Rock-salt*, a pure cleavable variety, or semitransparent *uncrystallized gypsum*, the transparent and crystallized varieties being generally too soft.
3. *Calcareous spar*, a cleavable variety.
4. *Fluor spar*, in which the cleavage is distinct.
5. *Apatite*, the asparagus-stone, or phosphate of lime, from Saltzburg.
6. *Adularia felspar*, any cleavable variety.
7. *Rock-crystal*, a transparent variety.
8. *Prismatic topaz*, any simple variety.
9. *Corundum* from India, which affords smooth cleavage surfaces.
10. The *Diamond*.

Two other degrees are obtained by interposing foliated mica between 2 and 3, and scapolite, a crystalline variety, between 5 and 6. The former is numbered 2·5, the latter 5·5.

To ascertain the hardness of a mineral, first try which of the members of the scale is scratched by it, and in order to save the specimens, begin with the highest numbers, and proceed downwards, until reaching one which is scratched. Then take a fine hard file, and draw along its surface, with the least possible force, the specimen to be examined, and also that mineral in the scale whose hardness is immediately above the one which has been scratched. From the resistance they offer to the file, from the noise occasioned by their passing along it, and from the quantity of powder left on its surface, their relative hardness is deduced. When, after repeated trials, we are satisfied to which member of the scale of hardness the mineral is most nearly allied, we say its hardness (suppose it to be felspar) is equal to 6, and write after it H. = 6·0. If the mineral do not exactly correspond with any degree of the scale, but is found to be between two of them, it is marked by the lower with a decimal figure added. Thus, if more than 6 but less than 7, it is expressed H. = 6·5. In these experiments we must be careful to employ specimens which nearly agree in form

and size, and also as much as possible in the shape of their angles.

Where the scale of hardness is wanting, or for a first rough determination, the following experiments may serve:—

Every mineral that is scratched by the finger-nail has H. = 2·5 or less.

Minerals that scratch copper have H. = 3 or more.

Polished white iron has H.=4·5.

Window-glass has H.=5 to 5·5.

Steel point or file has H.=6 to 7.

Hence every mineral that will cut or scratch with a good pen-knife has H. less than 6.

Flint has H.=7, and only about a dozen minerals, including the precious stones or gems, are harder.

Closely allied to hardness is the TENACITY of minerals, of which the following varieties have been distinguished:—A mineral is said to be *brittle* when, as in quartz, on attempting to cut it with a knife, it emits a grating noise, and the particles fly away in the form of dust. It is *sectile* or *mild* when, as in galena and some varieties of mica, on cutting, the particles lose their connection in a considerable degree; but this takes place without noise, and they do not fly off, but remain on the knife. And a mineral is said to be *soft* or *ductile* when, like native gold or lead, it can be cut into slices with a knife, extended under the hammer, and drawn into wire. From tenacity it is usual to distinguish *frangibility*, or the resistance which minerals oppose when we attempt to break them into pieces or fragments. This property must not be confounded with hardness. Quartz is hard, and hornblende comparatively soft; yet the latter is more difficultly frangible than the former. *Flexibility*, again expresses the property possessed by some minerals of bending without breaking. They are *elastic*, like mica, if, when bent, they spring back again into their former direction; or merely flexible, when they can be bent in different direc-

tions without breaking, but remain in their new position, as gypsum, talc, asbestus, and all malleable minerals.

Specific Gravity.

The density or the relative weight of a mineral, compared with an equal volume of pure distilled water, is named its specific gravity. This is a most important character for distinguishing minerals, as it varies considerably in different species, and can be readily ascertained with much accuracy, and in many cases without at all injuring the specimen. The whole process consists in weighing the body, first in air, and then immersed in water, the difference in the weight being that of an equal bulk of the latter fluid. Hence, assuming, as is commonly done, the specific gravity of pure distilled water to be equal to 1 or unity, the specific gravity (G) of the other body is equal to its weight in air (w), divided by the loss or difference (d) of weight in water (or $G = \frac{w}{d}$).

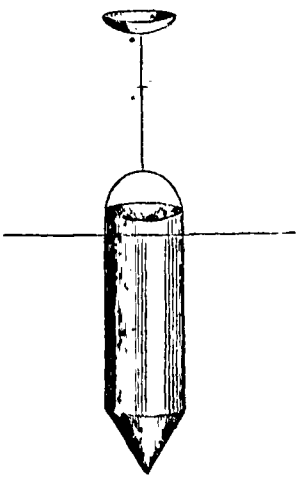


Fig. 94.

A simple and portable instrument for finding the specific gravity is the areometer of Nicholson, fig. 94. A delicate hydrostatic balance gives the gravity with far more accuracy; and even a good common balance is often preferable. The mineral may be suspended from one arm or scale by a fine silk thread or hair, and its weight ascertained, first in the air, and then in water.

There are a few precautions necessary to insure accuracy.

Thus, a pure specimen must be selected which is not intermixed with other substances, and when weighed in air it should be quite dry. It must also be free from cavities, and care must be taken that when weighed in water no globules of air adhere to its surface, which render it lighter. If the body imbibes moisture, it should be allowed to remain till fully saturated before determining its weight when immersed, and it is sometimes even necessary to boil the specimen in order to expel the air from its pores. Small crystals or fragments, whose freedom from mixture can be seen, are best adapted for this purpose. The specimen experimented on should not be too heavy; thirty grains being enough where the gravity is low, and even less where it is high. It is also of importance to repeat the trial, if possible with different specimens, which will show whether any cause of error exists, and to take the mean of the whole. A correction should be made for the variation of the temperature of the water from 60° Fahr., which is that usually chosen as the standard in mineralogical works. Where the difference, however, does not exceed ten or fifteen degrees this correction may be neglected, as it only affects the third or second decimal figure of the result.

Optical Properties of Minerals.

There are few more interesting departments of science than the relations of mineral bodies to light, and the modifications which it undergoes either when passing through them or when reflected from their surface. In this place, however, we can only notice these phenomena so far as they point out distinctions in the internal constitution of minerals, or furnish characters for distinguishing one species from another.

Minerals, and even different specimens of the same species, vary much in pellucidity or in the quantity of light which can pass through them. Some transmit so much light,

that small objects can be clearly seen, or letters read when placed behind them, and are named *transparent.* They are *semitransparent* when the object is only seen dimly, as through a cloud; and *translucent* when the light that passes through it is so obscured that the objects can be no longer discerned. Some minerals are only thus *translucent on the* thinnest *edges*, and in others even these transmit no light, and the body is named *opaque* or untransparent. These degrees pass gradually into each other, and cannot be separated by any precise line; and this is also the case in nature, where some minerals pass through the whole scale, as quartz, from the fine transparent rock-crystal to opaque dark-black varieties. Such minerals may be described generally as *pellucid.* This change often arises from some mixture in their composition, especially of metallic substances. Perfect opacity is chiefly found in the metals or their compounds with sulphur, though even these seem to transmit light when reduced to laminæ of sufficient thinness.

Double Refraction.—When a ray of light passes obliquely from one medium into another of different density, it is bent or refracted from its former course. The line which it then follows forms an angle with the perpendicular, which in each body bears a certain proportion to that at which the ray fell upon it, or, as definitely stated, the sine of the angle of refraction has a fixed ratio to the sine of the angle of incidence, this ratio being named the index of refraction. This simple refraction is common to all transparent bodies, whether crystalline, amorphous, or fluid; but some crystals produce a still more remarkable result. The ray of light which entered them as one is divided into two rays, each following different angles, or is doubly refracted. In minerals of the tesseral system this property does not exist, but it has been always observed in minerals belonging to the other systems, though in many only after they have been cut in a particular manner, or have been

otherwise properly prepared. It is most distinctly seen in crystals of calc-spar, especially in the beautiful transparent variety from Iceland, in which it was first observed and described by Erasmus Bartholin in a work published at Copenhagen in 1669.

The subjoined figure will illustrate this singular property. It represents a rhomb of Iceland spar, on the surface of which a ray of light *Rr* falls. As seen in the figure, this ray divides into two, one of which *roo'* follows the ordinary law of refraction, or the sines of the angles of incidence and refraction maintain a constant ratio. This is named the ordinary ray O. The other, hence named the extraordinary ray E, does not obey the usual law of the sines, and has no general index of refraction. In the plane perpendicular to the axis it is most widely separated from the ordinary ray, but in others oblique to it approaches nearer to O, and in one at right angles coincides, or there is no double refraction. This plane, or rather direction, in which there is no double refraction, is named the optical axis of the crystal, or the axis of double refraction. Now, in certain minerals, it is found that there is only one plane with this property, whereas in others there are two such planes, and they have in consequence been divided into monoaxial and binaxial. To the former (monoaxial) belong all crystals of the tetragonal and hexagonal systems; to the latter (binaxial) all those of the three other systems. In the former the optic

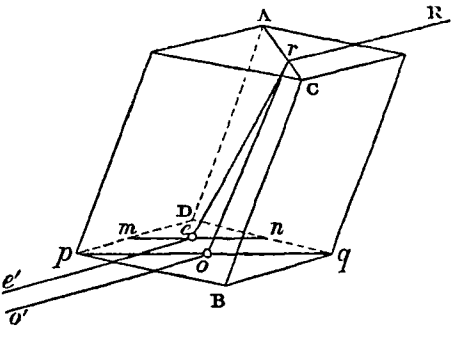


Fig. 95.

axis coincides with, or is parallel to, the crystallographic chief axis. In some crystals the index of refraction for the extraordinary ray E is greater than for the ordinary ray O; and in others it is smaller. The former are said to have positive (or attractive), the latter negative (or repulsive), double refraction. Quartz is an example of the former, the index of refraction, according to Malus, being for O = 1·5484, for E = 1·5582; and calc-spar of the latter, the index of O being = 1·6543, of E = 1·4833. The index of E is in both cases taken at its maximum.

It should be observed that the optic axes are not single lines, but directions parallel to a line, or innumerable parallel lines, passing through every atom of the crystal. It is also important to remark that this property divides the systems of crystallization into three precise groups,—the tesseral, with single refraction; the tetragonal and hexagonal, with double refraction, and monoaxial; the other three systems also double, but binaxial. It is therefore of use to determine the system to which a mineral belongs, but is not of great value as a character for distinguishing species.

Polarization of Light.—Intimately connected with this property is that of the polarization of light, which being more easily and precisely observable than double refraction, is in many cases of higher value as a mineralogical character. By this term is meant a peculiar modification which a ray of light undergoes, in consequence of which its capability of being transmitted or reflected towards particular sides is either wholly or partially destroyed. Thus, if from a transparent prism of tourmaline two thin plates are cut parallel to its axis, they will transmit light, as well as the prism itself, when they are placed above each other with the chief axis of both in the same direction. But when the one slip of tourmaline is turned at right angles to the other, either no light at all or very little is transmitted, and the plates consequently appear black. Hence, in passing through the first slip the rays of light have acquired a peculiar property,

which renders them incapable of being transmitted through the second, except in a parallel position, and they are then said to be polarized. The same property is acquired by a ray of light when reflected, at an angle of 35½° (or angle of incidence 54½°), from a plate of glass, one side of which is blackened, or from some other non-metallic body. When such a ray falls on a second similar mirror at an equal angle, but so that the plane of reflection in the second is at right angles to that in the first, it is no longer reflected, but wholly absorbed. When, on the other hand, the planes of reflection are parallel, the ray is wholly and at any intermediate angle partially reflected. A ray of light polarized by reflection is also incapable of transmission through a tourmaline slip in one position, which, however, is at right angles to that in which a ray polarized by passing through another slip is not transmitted.

In order to observe the polarization of light, a very simple instrument will be found useful (fig. 96). At one end of a horizontal board B a black mirror *a* is fixed. In the middle is a pillar to which a tube *cd* is fastened, with its axis directed to the mirror at an angle of 35½°.

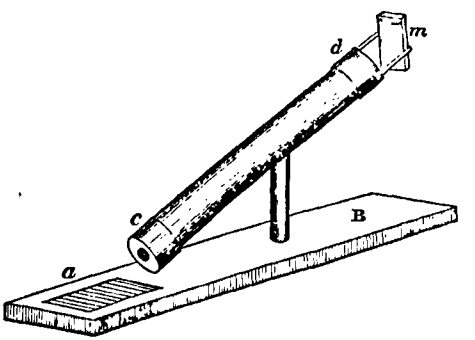


Fig. 96.

On the lower end is a cover *c*, with a small hole in the centre, and at the upper end another cover with a small black mirror *m* attached to it by two arms, as in the figure, and also at an angle of 35½°. With this instrument the mirror *m* can be so placed in relation to *a* that the planes

of reflection shall have any desirable inclination to exhibit the simple polarization of light.

This instrument furnishes a simple test whether minerals that cleave readily into thin lamellæ are optically monoaxial or binaxial. Place the two mirrors with their polarization-planes at right angles, and fix a plate of the mineral with a little wax over the hole *c*, and then observe what takes place in the second mirror during the time that the cover *c* is turned round. If the mineral belongs to the binaxial system, the light from the first mirror *a*, in passing through it, is doubly refracted and has its polarization changed, and consequently can be again reflected from the second mirror *m*, and in each revolution of *c* will show four maxima and four minima of intensity. If, on the contrary, the mineral is monoaxial, the ray will pass through the lamina unaltered, and will not be reflected from the second mirror in any position of *c*.

Another beautiful phenomenon of polarized light, in like manner connected with the crystalline structure of minerals, is the coloured rings which laminæ of the doubly-refracting species, when of a proper thickness, exhibit in certain positions. These rings are easily seen in the above apparatus by interposing a thin plate of gypsum or mica between the two mirrors. When the interposed plate belongs to a monoaxial mineral, there is seen in the second mirror a system of circular concentric coloured rings intersected by a black cross (fig. 97). If the mineral is binaxial, one or two systems of elliptical coloured rings appear, each intersected by a black stripe (fig. 98). In certain cases this stripe is curved, or the two systems of rings unite in

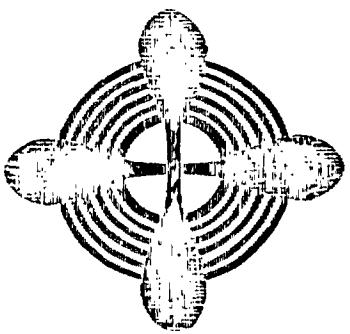


Fig. 97.

a lemniscoidal form (fig. 99). When the planes of polarization are parallel, the black cross and stripe appear white (fig.

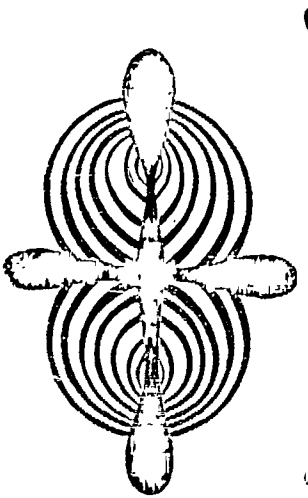


Fig. 98.

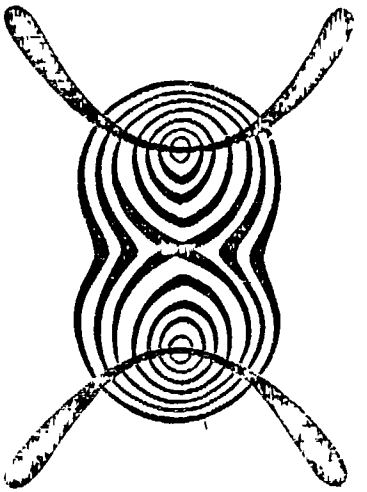


Fig. 99.

100), showing that in this direction the crystals act like singly-refracting minerals. Quartz, again, in close relation to its system of crystallization, exhibits a circular polarization of splendid prismatic colours, which, on turning the plate, change in each point in the order of the spectrum, from red to yellow, green, and blue. In order to produce these changes, however, in some specimens the plate must be turned to the right, in others to the left, showing a difference in the crystalline structure.



Fig. 100.

Pleochroism.—Closely connected with double refraction is that property of transparent minerals named pleochroism (many-coloured), in consequence of which they exhibit

distinct colours when viewed by transmitted light in different directions. Crystals of the tesseral system do not show this property; whilst in those of the other systems it appears in more or less perfection; and in the tetragonal and hexagonal minerals as dichroism (two colours), in the rhombic and clinohedric systems as trichroism (three colours). In most cases these changes of colour are not very decided, and appear rather as different tints or shades than as distinct colours. The most remarkable of dichromatic minerals are the magnesian mica from Vesuvius, the tourmaline and ripidolite; of trichromatic, the iolite, the andalusite from Brazil, the diaspore from Schemnitz, and the axinite.

Some crystalline minerals exhibit a very lively play or change of colours from reflected light in certain directions. It is well seen in many various hues on the cleavage-planes of Labrador felspar, and seems produced by a multitude of very thin quadrangular pores, interposed in the mineral like minute parallel laminæ. On the cleavage-planes of the hypersthene it appears copper-red, and is occasioned by numerous small brown or black laminæ of some foreign substance interposed in a parallel position between the planes of the hypersthene. The chatoyant, or changing colours of the sun-stone, arise from scales of iron-glance similarly interposed. The play of colour in the noble opal seems to be produced very nearly in the same manner with that in the labradorite. A similar opalescence is seen in certain minerals when cut in particular forms. In the sapphire, cut hemispherically over the chief axis, it appears like a star with six rays; in certain varieties of chrysoberl and adularia it has a bluish tint; and is also very remarkable in the cât's-eye variety of quartz. Iridescence often arises from very fine fissures, producing semicircular arches of prismatic tints, which, like the colours of thin plates in general, are referred to the interference of light.

Lustre and Colour.

Though these properties admit of no precise or mathematical determination, they are of considerable value in mineralogy. One highly important distinction founded on them is that of minerals of metallic and non-metallic aspect or character. This distinction can hardly be described in words, and the student will best learn to distinguish metallic colours and lustre from non-metallic by observing them in nature. Transparency and opacity nearly coincide with this division, the metallic minerals being almost constantly opaque; the non-metallic more or less transparent. Minerals which are perfectly opaque, and show metallic colour and lustre, are named metallic; those with only two of these three properties, semi-metallic or metalloid; and those with the opposite properties non-metallic.

Lustre has reference to the intensity and quality of the reflected light, considered as distinct from colour. Several degrees in intensity have been named. (1.) *Splendent*, when a mineral reflects light so perfectly as to be visible at a great distance, and lively, well-defined images are formed in its faces, as galena, rock-crystal, or calc-spar. (2.) *Shining*, when the reflected light is weak, and only forms indistinct and cloudy images, as heavy spar. (3.) *Glistening*, when the reflected light is so feeble as not to be observable at a greater distance than arm's length, and the surface can no longer form an image. (4.) *Glimmering*, when the mineral held near the eye in full clear daylight presents only a number of small shining points, as red hæmatite and granular limestone. When, as in chalk, the lustre is so feeble as to be indiscernible, it is said to be *dull*.

In regard to the kind or quality of the lustre, the following varieties are distinguished:—(1.) The *metallic*, seen in much perfection in native metals and their compounds with sulphur, and imperfectly in glance coal. (2.) *Ada-*

mantine, found in beautiful perfection in the diamond, and in some varieties of blende and carbonate of lead. (3.) *Vitreous* or glassy, seen in rock-crystal or common glass, or inclining to adamantine in flint-glass. (4.) *Resinous*, when the body appears as if smeared with oil, as in pitch-stone and garnet. (5.) *Pearly*, like mother-of-pearl, seen in stilbite, gypsum, mica. (6.) *Silky*, the glimmering lustre seen on fine fibrous aggregates like amianthus.

Colour.—This property is not in all cases of equal value as a character. Thus some minerals are naturally coloured, showing in all modes of their occurrence one determinate colour, which is therefore essential, and forms a characteristic of the species. This class includes the metals, pyrites, blendes, with many metallic oxides and salts. A second class of minerals are colourless, their purest forms being white, or clear like water, as ice, calc-spar, quartz, adularia, and many silicates. But these minerals are occasionally coloured,—that is, accidentally tinged, sometimes from the chemical or mechanical admixture of some colouring substance, as a metallic oxide, carbon, or particles of coloured minerals; at other times from the substitution of a coloured for an uncoloured isomorphous element. The colours of these minerals therefore vary indefinitely, and can never characterize the species, but only its varieties. Thus, quartz, calc-spar, fluor spar, gypsum, and felspar are often coloured accidentally by pigments mechanically mixed; and hornblende, augite, garnet, and other colourless silicates acquire green, brown, red, or black tints from the introduction of the isomorphic colouring elements.

Werner, who bestowed much attention on this portion of mineralogy, distinguished eight principal colours,—white, gray, black, blue, green, yellow, red, and brown,—each with several varieties or shades arising from intermixture with the other colours. He also divided them into metallic and non-metallic as follows:—

METALLIC COLOURS.

1. *White.*—(1.) Silver-white, as in leucopyrite and native silver. (2.) Tin-white; native antimony.

2. *Gray.*—(1.) Lead-gray; galena or lead glance. (2.) Steel-gray; native platina.

3. *Black.*—(1.) Iron-black; magnetite.

4. *Yellow.*—(1.) Brass-yellow; chalcopyrite. (2.) Bronze-yellow; iron pyrites. (3.) Gold yellow; native gold.

5. *Red.*—(1.) Copper-red; native copper and nickeline.

NON-METALLIC COLOURS.

1. *White.*—(1.) Snow-white; new fallen snow, Carrara marble, and common quartz. (2.) Reddish-white; heavy spar. (3.) Yellowish-white; chalk. (4.) Grayish-white; quartz. (5.) Greenish-white; amianthus. (6.) Milk-white; skimmed milk, chalcedony.

2. *Gray.*—(1.) Bluish-gray; limestone. (2.) Pearl-gray; porcelain jasper, and rarely quartz. (3.) Smoke-gray or brownish-gray; dense smoke, dark varieties of flint. (4.) Greenish-gray; clay-slate and whet-slate. (5.) Yellowish-gray; chalcedony. (6.) Ash-gray; wood-ashes, zoisite, zircon, and slate-clay.

3. *Black.*—(1.) Grayish-black; basalt, Lydian stone, and lucullite. (2.) Velvet-black; obsidian and schorl. (3.) Pitch-black or brownish-black; cobalt ochre, bituminous coal, and some varieties of mica. (4.) Greenish-black or raven-black; hornblende. (5.) Bluish-black; fluor spar.

4. *Blue.*—(1.) Blackish-blue; dark varieties of azurite. (2.) Azure-blue; bright varieties of azurite and Lapis lazuli. (3.) Violet-blue; amethyst and fluor spar. (4.) Lavender-blue; lithomarge and porcelain jasper. (5.) Plum-blue; spinel and fluor spar. (6.) Berlin-blue; sapphire, rock-salt, cyanite. (7.) Smalt-blue; pale-coloured smalt, gypsum. (8.) Duck-blue; talc and corundum. (9.) Indigo-blue; earthy-blue iron or vivianite. (10.) Skye-blue; liroconite, some varieties of fluor spar and of blue spar.

5. *Green.*—(1.) Verdigris-green; amazon stone and liroconite. (2.) Celandine-green; green earth, Siberian and Brazilian beryl. (3.) Mountain-green; beryl, aqua-marine topaz. (4.) Leek-green; common actynolite and prase. (5.) Emerald-green; emerald, and some varieties of green malachite. (6.) Apple-green; chrysoprase. (7.) Grass-green; uranite, smaragdite. (8.) Blackish-green; augite and precious serpentine. (9.) Pistachio-green; chrysollte and epi-

dote. (10.) Asparagus-green; the apatite or asparagus-stone from Spain and Salzburg. (11.) Olive-green; garnet, pitch-stone, and olivine. (12.) Oil-green; olive-oil, blende, beryl. (13.) Siskin-green; uranite, and some varieties of pyromorphite.

6. *Yellow.*—(1.) Sulphur-yellow; native sulphur. (2.) Straw-yellow; pycnite and karpholite. (3.) Wax-yellow; opal and wulfenite. (4.) Honey-yellow; dark honey, fluor spar, and beryl. (5.) Lemon-yellow; rind of ripe lemons, orpiment. (6.) Ochre-yellow; yellow-earth and jasper. (7.) Wine-yellow; Saxon and Brazilian topaz and fluor spar. (8.) Cream-yellow or Isabella-yellow; bole from Strigau, and compact limestone. (9.) Orange-yellow, rind of the ripe orange, uran-ochre, and some varieties of wulfenite.

7. *Red.*—(1.) Aurora, or morning-red; realgar. (2.) Hyacinth-red; hyacinth or zircon, and garnet. (3.) Tile-red; fresh-burned bricks, porcelain-jasper, and heulandite. (4.) Scarlet-red; light-red cinnabar. (5.) Blood-red; blood, pyrope. (6.) Flesh-red; felspar and barytes. (7.) Carmine-red; carmine, spinel, particularly in thin splinters. (8.) Cochineal-red; cinnabar and certain garnets. (9.) Crimson-red; oriental ruby and erythrine. (10.) Columbine-red; precious garnet. (11.) Rose-red; diallogite and rose-quartz. (12.) Peach-blossom red; blossoms of the peach, red cobalt-ochre. (13.) Cherry-red; spinel, kermes, and precious garnet. (14.) Brownish-red; reddle and columnar-clay ironstone.

8. *Brown.*—(1.) Reddish-brown; brown blende from the Hartz, and zircon. (2.) Clove-brown; the clove, rock-crystal, and axinite. (3.) Hair-brown; wood-opal and limonite. (4.) Broccoli-brown; zircon. (5.) Chesnut-brown; Egyptian jasper. (6.) Yellowish-brown; iron-flint and jasper. (7.) Pinchbeck-brown; tarnished pinchbeck, mica. (8.) Wood-brown; mountain wood and old rotten wood. (9.) Liver-brown; boiled liver, common jasper. (10.) Blackish-brown; mineral pitch and brown coal.

The accidentally coloured minerals sometimes present two or more colours or tints, even on a single crystal; very remarkable examples occurring in fluor spar, apatite, sapphire, amethyst, tourmaline, and cyanite. This is still more common in compound minerals, on which the colours are variously arranged in points, streaks, clouds, veins, stripes, bands, or in brecciated and ruin-like forms. Some minerals again change their colour from exposure to the light,

the air, or damp. Sometimes merely the surface is affected or *tarnished*, and then appears covered as with a thin film, producing in some minerals, as silver, arsenic, bismuth, only one colour; in others, as copper pyrites, hæmatite, stibine, and common coal, various or iridescent hues. Occasionally the change pervades the whole mineral, the colour sometimes becoming paler, or disappearing, as in chrysoprase and rose-quartz; at other times darker, as in brown spar, siderite, and rhodonite. In a few minerals a complete change of colour takes place, as in the chlorophæite of the Western Isles, which, on exposure for a few hours, passes from a transparent yellow-green to black. These mutations seem generally connected with some chemical change. The tarnished colours sometimes only appear on certain faces of a crystal belonging to a peculiar form. Thus a crystal of copper pyrites (like fig. 35) has one face P′ free from tarnish; the faces *b* and *c*, close to P′, are dark blue; the remainder of *c*, first violet, and then, close to P, gold-yellow. The colour of the powder formed when a mineral is scratched by a hard body is often different from that of the solid mass. This is named the *streak*, and is very characteristic of many minerals. It also often shows a peculiar lustre where the mineral is soft, as in talc and steatite.

Phosphorescence, Electricity, Magnetism.

Phosphorescence is the property possessed by particular minerals of producing light in certain circumstances without combustion or ignition. Thus some minerals appear luminous when taken into the dark after being for a time exposed to the sun's rays, or even to the ordinary daylight. Many diamonds and calcined barytes exhibit this property in a remarkable degree; less so, arragonite, calc-spar, and chalk; and in a still inferior degree, rock-salt, fibrous gypsum, and fluor spar. Many minerals, including the greater part of those thus rendered phosphorescent by the influence

of the sun, also become so through heat. Thus some topazes, diamonds, and varieties of fluor spar become luminous by the heat of the hand; other varieties of fluor spar and the phosphorite require a temperature near that of boiling water; whilst calc-spar and many silicates are only phosphorescent at from 400° to 700° Fahr. Electricity produces it in some minerals, as in green fluor spar and calcined barytes. In others it is excited when they are struck, rubbed, split, or broken; as many varieties of zinc-blende and dolomite when scratched with a quill, pieces of quartz when rubbed on each other, and plates of mica when suddenly separated.

Friction, pressure, and heat also excite *electricity* in minerals. To observe this property delicate electroscopes are required, formed of a light needle, terminating at both ends in small balls, and suspended horizontally on a steel pivot by an agate cup. Such an instrument can be negatively electrified by touching it with a stick of sealing-wax, excited by rubbing, or positively when the wax is only brought so near as to attract the needle. When the instrument is in this state the mineral, if also rendered electric by heat or friction, will attract or repel the needle according as it has acquired electricity of an opposite or similar kind; but if the mineral is not electric, it will attract the needle in both conditions alike. Most precious stones become electrical from friction, and are either positive or negative according as their surface is smooth or rough. Pressure even between the fingers will excite distinct positive electricity in pieces of transparent double-refracting calc-spar. Topaz, arragonite, fluor spar, carbonate of lead, quartz, and other minerals show this property, but in a much smaller degree.

Heat or change of temperature excites electricity in many crystals, as in tourmaline, calamine, topaz, calc-spar, beryl, barytes, fluor spar, diamond, garnet, and others, which are hence said to be thermo- or pyro-electric. Some acquire

polar pyro-electricity, or the two electricities appear in opposite parts of the crystal, which are named its electric poles. Each pole is alternately positive and negative,—the one when the mineral is heating, the other when it is cooling. The poles that become positive during an increase of temperature are named analogue; those that become negative in the same condition, antilogue poles, as shown in this table:—

Temperature.	Produces	Electricity.
+ or rising − or falling	in analogue poles	+ or vitreous. − or resinous.
+ or rising − or falling	in antilogue poles	− or resinous. + or vitreous.

As already noticed, many polar electric minerals are also remarkable for their hemimorphic crystal forms. The number and distribution of the poles likewise vary. In many monoaxial minerals, as tourmaline and calamine, there are only two poles, one at each end of the chief axis; whereas boracite has eight poles corresponding to the angles of the cube. In prehnite and topaz, again, two antilogue poles occur on the obtuse lateral edges of the prism ∞P, and one analogue pole corresponding to the macrodiagonal chief section, or in the middle of the diagonal joining the obtuse edges.

Magnetism, or the power to act on the magnetic needle, is very characteristic of the few minerals in which it occurs, chiefly ores of iron or nickel. It is either simple, attracting both poles of the needle; or polar, when one part attracts, and another repels the same pole. Some magnetic iron ores, or natural magnets, possess polar magnetism; whilst the common varieties, meteoric iron, magnetic pyrites, precious garnet, and other minerals, are simply magnetic. Most minerals are only attracted by the magnet, but do not themselves attract iron.

Smell, taste, and *touch* furnish a few characters of minerals. Most have no smell, but some give out a peculiar odour when rubbed: as quartz, an empyreumatic odour, or smell

of burning; fluor spar, of chlorine; clay, of clay; some limestones and marls, of bitumen, or a fœtid odour. Aluminous minerals acquire a smell when breathed on. Other odours caused by heat, and often highly characteristic, are noticed under tests by the blow-pipe.

Taste is produced by all the salts soluble in water. Some are saline, like common salt; sweetish astringent, like alum; astringent, like blue vitriol; bitter, like epsom salt; cooling, like saltpetre; pungent, like sal-ammoniac; alkaline, like soda; acid or sour, like sassoline, &c.

Touch.—Some minerals are distinguished by a greasy feeling, like talc; others feel meagre, like clay; others cold. The last character readily distinguishes true gems from their imitations in glass.

CHAPTER III.

CHEMICAL PROPERTIES OF MINERALS.

The consideration of the chemical nature of minerals,—that is, of the elements that enter into their composition,—of the manner in which these elements combine, and the variations in proportion which they may undergo without destroying the identity of the species, forms an important branch of mineralogical science. The methods of detecting the different elements, and the characters which are thus furnished for the discrimination of minerals, are also of much value. This is especially true of the metallic ores and other substances, sought not as objects of curiosity, but for their economic qualities.

Composition of Minerals.

At present about sixty elements, or substances which have not been decomposed, are known. These are divided

into *metallic* and *non-metallic*, a distinction of importance in mineralogy, though not always to be carried out with precision. The non-metallic elements are rarely of semimetallic aspect, and are bad conductors of heat and electricity. Some are commonly gaseous—oxygen, hydrogen, nitrogen, chlorine, and fluorine; one fluid—bromine; the others solid—carbon, phosphorus, sulphur, boron, selenium, and iodine. The metallic elements are, except mercury, solid at usual temperatures, have generally a metallic aspect, and are good conductors of heat and electricity. They are divided into *light* and *heavy* metals, the former with a specific gravity under 5, and a great affinity for oxygen, and again distinguished as either alkali-metals, potassium (or kalium), sodium (or natrium), lithium, barium, strontium, and calcium;—or earth-metals, magnesium, lanthanium, yttrium, glucinum, aluminium, zirconium, silicium. The heavy metals, with a specific gravity above 5, are divided into *noble*, which can be reduced, or separated from oxygen, by heat alone; and *ignoble*, whose affinity for oxygen renders them irreducible without other agents. Some of the latter are brittle and difficultly fusible;—thorium, titanium, tantalium (columbium), tungsten (wolframium), molybdenum, vanadium, chromium, uranium, manganese, and cerium; others are brittle and easily fusible or volatile—arsenic, antimony, tellurium, and bismuth; and others malleable—zinc, cadmium, tin, lead, iron, cobalt, nickel, and copper. The noble metals are,—quicksilver, silver, gold, platinum, palladium, rhodium, iridium, and osmium.

All the chemical combinations observed in the mineral kingdom follow the law of definite proportions; that is, two elements always combine either in the same proportion, or so that the quantity of the one is multiplied by two, three, four, or some other definite number seldom very large. As the same law prevails throughout the whole range of elements, by assuming any one, usually hydrogen or oxygen, as unity or 1, and determining from experiment the simple

proportion in which the others combine with it, a series of numbers is obtained which also expresses the proportions in which all these elements combine with each other. These numbers, therefore, mark the combining proportions or equivalents, as they are named, of the elements. They are also named atomic weights, on the supposition that matter consists of definite atoms, and that its combinations consist of one atom (or sometimes two atoms) of one substance, with one, two, three, or more atoms of another This theory is not free from difficulties, but the language is often convenient. To designate the elements chemists generally employ the first letter or letters of their Latin names. These signs also indicate one atom or equivalent of the element. Thus, O means oxygen in the proportion of one atom; H, hydrogen in the same proportion; N, an atom of nitrogen; Na, an equivalent proportion of natrium or sodium. These signs and the equivalent weights are given in the table on next page, in one column of which hydrogen is taken as unity, in the other oxygen. The elements are arranged according to Berzelius, beginning with the most electro-positive, and ending with the most electro-negative.

All these elements occur in minerals, but not more than twenty are common, and only about twelve abundant. They are also very rare in their simple or uncombined state; only carbon in the diamond and graphite, sulphur, and about a dozen of the native metals, being thus known. More frequently minerals consist of two or more elements combined in accordance with those laws which prevail in inorganic compounds. The most important of these laws is that the combinations are binary; that is, that the elements unite in pairs, which may again unite either with another compound of two, or with a single element. Inorganic compounds also are generally distinguished from organic by their greater simplicity.

TABLE I.—*Elements arranged in Electro-Chemical order.*

Name.	Sign.	Atomic Weight. H=1	Atomic Weight. O=100.	Name.	Sign.	Atomic Weight. H=1	Atomic Weight. O=100.
Potassium....	K	39·2	488·85	Glucinum	♀	7	86·5
Sodium.....	Na	23·2	290·9	Aluminium	Al	13·7	*342·33
Lithium.....	Li	7	86·9	Zirconium ...	Zr	22·5	*840·4
Ammonium..	NH^2	17	...	Thorium	Th	59·6	744·90
Barium.....	Ba	68·6	856·88	Cerium.....	Ce	46	575
Strontium....	Sr	44	547·28	Lanthanium	La	36?	...
Calcium.....	Ca	20	251·5	Didymium...	D	...	...
Magnesium..	Mg	12·5	154·5	Uranium	U	60	746·36
Yttrium	Y	32	402·51	Manganese...	Mn	28	345·89
Iron	Fe	28	350·53	Boron	B	11	136·2
Nickel.....	Ni	29	362·8	Titanium	Ti	25	303·68
Cobalt.....	Co	30	375	Tantalium...	Ta	185	1153·715
Zinc.....	Zn	32·2	406·59	Niobium	Nb	...	...
Cadmium.....	Cd	56	696·76	Pelopium ?...	Pp	...	...
Tin	Sn	59	735·29	Wolframium	W	92	1150·78
Lead.....	Pb	104	1294·5	Molybdenum	Mo	46	575 83
Bismuth.....	Bi	208	*2600	Vanadium...	V	66·6	855·8
Copper	Cu	31·7	395·69	Chromium ...	Cr	26·3	328·59
Mercury.....	Hg	100	1250	Tellurium....	Te	64	802·12
Silver	Ag	108	1349·66	Antimony ...	Sb	122	1529·2
Palladium....	Pd	53·3	665·84	Arsenic	As	75	*940·08
Rhodium.....	Rh	52	651·4	Phosphorus..	P	31	*392·28
Ruthenium...	Ru	...	...	Nitrogen.....	N	14	*175·06
Iridium	Ir	99	1233·26	Selenium.....	Se	40	494·58
Platinum	Pt	99	1233·26	Sulphur	S	16	200·75
Osmium	Os	99	1244·21	Oxygen	O	8	100
Gold.....	Au	168	*2458·83	Iodine.....	I	126	*1586
Hydrogen ...	H	1	*12·48	Bromine.....	Br	78·4	*999·62
Silicium.....	Si	15 † / 22·2 ‡	†187·5 / ‡277·31	Chlorine.....	Cl	36	*443·28
Carbon	C	6	75·415	Fluorine	F	18·7	*233·80

* Double atoms.
† L. Gmelin, who considers silica as composed of one atom base and two oxygen.
‡ Berzelius.

The above list includes ammonium, usually considered a compound body, and omits the two new metals, erbium and terbium.

The following principles are observed in designating the

combinations of these elementary substances:—For those of the first order the signs of the two components are conjoined, and the number of atoms or equivalents of each expressed by a number following the sign like an algebraic exponent. Thus, SO, SO^2, SO^3, are the combinations of one atom sulphur with one, two, and three atoms of oxygen; FeS, FeS^2, of one atom of iron with one or two of sulphur. But as combinations with oxygen and sulphur are very numerous in the mineral kingdom, Berzelius, to whom science is indebted for this system of signs, marks the atoms of oxygen by dots over the sign of the other element, and those of sulphur by an accent; the above compounds being then designated thus—Ṡ, S̈, S⃛, and Fe', Fe". In some cases two atoms of a base combine with three or five of oxygen or sulphur, as Al^2O^3, Fe^2S^3. In such cases Berzelius marks the double atom by a line drawn through the sign of the single atom; thus, $\dddot{\text{Al}}$ is two atoms aluminium with three of oxygen or alumina; Ċu, two of copper with one of oxygen or oxide of copper. Where a number is prefixed to the sign like a coefficient in algebra it includes both elements of the combination; thus Ḣ is one atom water, 2 Ḣ two; ĊaĊ is one atom carbonate of lime, 2 ĊaĊ two atoms, including of course two of calcium, two of carbon, and six of oxygen.

The most common and important binary compounds are those with oxygen, contained in the following table, with their signs, atomic numbers, and amount of oxygen in 100 parts. The more electro-negative are named acids, which are often soluble in water, and then render blue vegetable colours red. The more electro-positive are named oxides or bases, and show great affinity or attractive power for the former. The most powerful are the alkaline bases, which are colourless and soluble in water; less powerful are the earths, also colourless, but insoluble in water;—

TABLE II.—*Binary Compounds with Oxygen.*

Name.	Sign.	Atomic Weight. H=1.	Atomic Weight. O = 100.	Oxyg. in 100 parts.
Alumina	$\dddot{Al}$	51·4	642·33	46·70
Antimony oxide	$\dddot{Sb}$	146	1829·2	16·40
Antimonious acid	$\ddot{Sb}$	154	1929·2	20·73
Antimonic acid	$\dddot{Sb}$	162	2029·2	24·64
Arsenious acid	$\dddot{As}$	99	1240·08	...
Arsenic acid	$\dddot{As}$	115	1440·08	34·72
Baryta	$\dddot{Ba}$	76·6	956·88	10·45
Bismuth peroxide	$\dddot{Bi}$	232	2900·00	10·34
Boracic acid	$\dddot{B}$	34·8	436·20	68·78
Carbonic acid	$\dddot{C}$	22	275·0	72·73
Cerium protoxide	$\dot{Ce}$	54	674·72	14·82
... peroxide	$\ddot{Ce}$	116	1449·39	20·70
Chromium oxide	$\ddot{Cr}$	76·6	956·78	31·35
Chromic acid	$\dddot{Cr}$	50·3	628·39	47·74
Cobalt protoxide	$\dot{Co}$	38	475	21·05
Copper suboxide (red)	$\dot{Cu}$	71·4	891·39	11·12
... protoxide (black)	$\dot{Cu}$	39·7	495·69	20·17
Glucina	$\ddot{G}$	38	490·05	63·26
Iron protoxide	$\dot{Fe}$	36	450·527	22·19
... peroxide (red)	$\ddot{Fe}$	80	1001·054	29·97
... proto-peroxide (black)	$\dot{Fe} + \ddot{Fe}$	116	1451·581	26·08
Lead protoxide	$\dot{Pb}$	112	1394·50	7·17
Lime or Calcia	$\dot{Ca}$	28	351·489	28·45
Lithia	$\dot{Li}$	15	186·9	53·50
Magnesia	$\dot{Mg}$	21	254·50	39·30
Manganese protoxide	$\dot{Mn}$	36	445·89	22·43
... peroxide	$\ddot{Mn}$	80	991·77	30·25
... proto-perox. (red)	$\dot{Mn} + \ddot{Mn}$	116	1437·66	26·34
Molybdic acid	$\ddot{Mo}$	70	875·83	34·28
Nickel protoxide	$\dot{Ni}$	37	462·8	21·60
Nitric acid	$\dddot{N}$	54	675·06	74·07
Phosphoric acid	$\dddot{P}$ or $\dddot{\mathbf{P}}$	71	892·28	56·04
Potassa	$\dot{K}$	47·2	588·856	16·98
Silica (Gmelin)	$\ddot{Si}$	31	387·5	51·61
... (Berzelius)	$\dddot{Si}$	46·2	577·31	51·96
Soda	$\dot{Na}$	31·2	390·90	25·58
Strontia	$\dot{Sr}$	52	647·29	15·45
Sulphuric acid	$\dddot{S}$	40	500·75	59·91
Tantalic acid	$\dddot{Ta}$	209	2607·43	11·51
Thorina	$\dot{Th}$	67·6	844·90	13·34
Tin peroxide	$\ddot{Sn}$	75	935·29	21·38
Titanic acid	$\ddot{Ti}$	41	503·68	39·71
Tungstic acid	$\ddot{W}$	116	1450·78	20·67
Uranium protoxide	$\dot{U}$	68	842·84	13·33
... peroxide	$\ddot{U}$	144	1792·72	10·13
Vanadic acid	$\dddot{V}$	92	1155·84	26·19
Water	$\dot{H}$	9	112·48	88·89
Yttria	$\dot{Y}$	40	502·51	19·90
Zinc oxide	$\dot{Zn}$	40·2	506·59	19·74
Zirconia	$\dot{Zr} - \dddot{Zr}$	30·4	114·2	26·37

NOTE.—In this table double atoms are indicated by the black letters, or **Al** = $\dddot{Al}$, **Fe** = $\ddot{Fe}$, &c.

Similar to the compounds of oxygen are those with sulphur, usually named sulphurets, and considered analogous to the oxidized bases. A few of more electro-negative character, resembling acids, have been distinguished as sulphides. Some other compounds have been named haloid salts, and consist of certain electro-negative elements, combined with electro-positive ones, as bases.

Many of these combinations occur as independent species in the mineral kingdom, especially those with oxygen and sulphur. Thus the most abundant of all minerals, quartz, is an oxide, and corundum is of similar nature. Many oxides of the heavy metals, as of iron, tin, copper, and antimony; and some super-oxides, as of lead and manganese (pyrolusite),—are very common. Compounds with sulphur also abound, and either as sulphides, with the character of acids, like realgar, orpiment, and stibine; or as sulphurets, resembling bases, like galena, argentite, and pyrite. Less frequent are haloid salts, with chlorine and fluorine, as common salt and fluor spar; and still rarer those with iodine and bromine. On the other hand, metallic alloys, or combinations of electro-negative with electro-positive metals, are far from uncommon, especially those with arsenic, tellurium, or antimony.

Combinations of these binary compounds with each other are still more common, the greater number of minerals being composed of an acid and base. By far the greater number are oxygen-salts, distinguished by giving to the acid the termination *ate*; thus sulphate of lead, silicate of lime, and in like manner numerous carbonates, phosphates, arseniates, aluminates. The sulphur-salts (two metals combined with sulphur, and these again combined with each other) are next in number, and perform a most important part in the mineral kingdom. The hydrates, or combinations of an oxide with water, are also common, and much resemble the oxygen salts, the water sometimes acting as an electro-positive, at other times as an electro-negative element.

Combinations of a higher order are likewise common, especially the double salts, or the union of two salts into a new body; and even these again with water, as alum and many hydrous silicates. The chemical formula for these compound salts are formed by writing the signs of the simple salts with the sign of addition between them: thus $\dot{Ca}\,\ddot{C} + \dot{Mg}\,\ddot{C}$, *i.e*, carbonate of lime and carbonate of magnesia, or brown spar; $\dddot{Al}\,\ddot{Si}^3 + \dot{K}\,\ddot{Si}^3$, or orthoclase; $3\,Na\,F + Al^2\,F^3$, or cryolite, composed of three compound atoms of fluorine and sodium united to one compound atom, consisting of three of fluorine and two of aluminium.

Influence of the Chemical Composition on the External Characters of Minerals.

That the characters of the compound must in some way or other depend on those of its component elements, seems, as a general proposition, to admit of no doubt. Hence it might be supposed possible, from a knowledge of the composition of a mineral, to draw conclusions in reference to its form and other properties; but practically this has not yet been effected. The distinction between the mineralizing and mineralizable, or the forming and formed, elements, lies at the foundation of all such inquiries. Certain elements in a compound apparently exert more than an equal share of influence in determining its physical properties. Thus the more important non-metallic elements, as oxygen, sulphur, chlorine, fluorine, are remarkable for the influence they exert on the character of the compound. The sulphurets, for example, have more similarity among themselves than the various compounds of one and the same metal with the non-metallic bodies. Still more generally it would appear that the electro-negative element in the compound is the most influential, or exerts the greatest degree of active forming power. After the non-metallic

elements the brittle, easily fusible metals rank next in power; then the ductile ignoble metals; then the noble metals; then the brittle, difficultly fusible; and last of all, the metals of the earths and alkalies.

It is sometimes stated that each particular substance can crystallize only in one particular form or series of forms. This is, however, only partially true; and sulphur, for instance, which usually crystallizes in the rhombic system, when melted may form monoclinohedric crystals. This property is named *dimorphism;* and hence the same chemical substance may form two, or even more, distinct bodies or mineral species. Thus carbon in one form is the diamond, in another graphite; carbonate of lime appears as calc-spar or arragonite; the bisulphuret of iron as pyrite and marcasite. An example of trimorphism occurs in the titanic acid, forming the three distinct species, anatase, rutile, and brookite. Even the temperature at which a substance crystallizes influences its forms, and so far its composition, as seen in arragonite, Glauber salt, natron, and borax.

Still more important is the doctrine of *isomorphism*, designating the fact that two or more simple or compound substances crystallize in one and the same form; or often in forms which, though not identical, yet approximate very closely. This similarity of form is generally combined with a similarity in other physical properties. Among minerals that crystallize in the tesseral form, isomorphism is of course common and perfect, there being no diversity in the dimensions of the primary form; but for this very reason it is of less interest. It is of more importance among mono-axial crystals, the various series of which are separated from each other by differences in the proportion of the primary form. In these perfect identity is seldom observed, but only very great similarity.

The more important isomorphic substances are the following:—

I. Simple substances:—
  (1.) Fluorine and chlorine.
  (2.) Sulphur and selenium.
  (3.) Arsenic, antimony, tellurium.
  (4.) Cobalt, iron, nickel.
  (5.) Copper, silver, quicksilver, gold (?).

II. Combinations with oxygen:—
  (1.) Of the formula $\dot{R}$.
    (*a.*) Lime, magnesia, protoxide of iron, protoxide of manganese, oxide of zinc, oxide of nickel, oxide of cobalt, potassa, soda.
    (*b.*) Lime, baryta, strontia, lead-oxide.
  (2.) Of the formula $\dddot{R}$.
    (*a.*) Alumina, peroxide of iron, peroxide of manganese, oxide of chromium.
    (*b.*) Antimony oxide, arsenious acid.
  (3.) Formula $\ddot{R}$. Tin-oxide, titanium-oxide.
  (4.) Formula $\ddot{\dot{R}}$. Phosphoric acid, arsenic acid.
  (5.) Formula $\dddot{R}$.
    (*a.*) Sulphuric acid, selenic acid, chromic acid, manganese acid.
    (*b.*) Tungstic acid, molybdic acid.

III. Combinations with sulphur:—
  (1.) Formula R'. Sulphuret of iron Fe', and sulphuret of zinc Zn'.
  (2.) Formula R'''. Sulphuret of antimony Sb''', and sulphuret of arsenic As'''.
  (3.) Formula R'. Sulphuret of copper Cu', and sulphuret of silver Ag'.

These substances are named vicarious, from the singular property that in chemical compounds they can mutually replace each other in indefinite proportions, and very often without producing any important change in the form or

other physical properties. But there are numerous instances among the silicates, where the mutual replacement of the isomorphic bodies, especially when the oxides of the heavy metals come in the room of the earths and alkalies, exerts a most essential influence on the external aspect of the species, particularly in regard to colour, specific gravity, and transparency. The varieties of hornblende, augite, garnet, epidote, and many other minerals, are remarkable proofs of this influence. This intermixture of isomorphic elements confers many valuable properties on minerals, and to it this department of nature owes much of its variety and beauty. Without the occasional presence of the colouring substances, especially the oxides of iron and manganese, the non-metallic combinations would have exhibited a very monotonous aspect. It is also remarkable that in some silicates the substitution of a certain portion of the metallic oxides for the earthy bases seems to be almost a regular occurrence; whilst in others, as the felspars and zeolites, this rarely happens. This fact is of very great economic importance, as drawing attention to important elements often combined with others of less value. Thus iron oxide and chrome oxide, sulphuret of copper and sulphuret of silver, nickel and cobalt, may be looked for in connection. The general chemical formula for such compounds is formed by writing R (= radicle or basis) for the whole isomorphic elements; and in special instances to place their signs either one below the other, connected by a bracket, or, as is more convenient, to inclose them in brackets one after the other, separated by a comma. Thus the general sign for the garnet is $\dot{R}^3\,\ddot{S}i^2 + \dddot{R}\,\ddot{S}i$, which, when fully expressed, becomes $\left.\begin{matrix}\dot{Ca}^3\\ \dot{Fe}^3\\ \dot{Mn}^3\end{matrix}\right\}\ddot{S}i^2 + \left\{\begin{matrix}\dddot{Al}\\ \dddot{Fe}\end{matrix}\right\}\ddot{S}i$; or $(\dot{Ca}^3, \dot{Fe}^3, \dot{Mn}^3)\,\ddot{S}i^2 + (\dddot{Al}, \dddot{Fe})\,\ddot{S}i$, and the mineral forms many varieties, as the one or other element predominates.

Chemical Reaction of Minerals.

The object of the chemical examination of minerals is the discovery of those elementary substances of which they consist. This examination is named *qualitative* when the nature of the elements alone, *quantitative* when also their relative amount, is sought to be determined. Mineralogists are in general content with such an examination as will discover the more important elements, and which can be carried on with a simple apparatus, and small quantities of the substance investigated. The indications thus furnished of the true character of the mineral are, however, frequently of high importance. Two methods of testing minerals are employed, the one by heat chiefly applied through the blow-pipe, the second by acids and other reagents in solution.

Use of the Blowpipe.

The blowpipe in its simplest form is merely a conical tube of brass or other metal, curved round at the smaller extremity, and terminating in a minute circular aperture not larger than a fine needle. Other forms have been proposed, one of the most useful being a cone of tin open for the application of the mouth at the smaller end, and with a brass or platina beak projecting from the side near the other or broad end. With this instrument a stream of air is conveyed from the mouth to the flame of a lamp or candle, so that this can be turned aside, concentrated, and directed upon any small object. The flame thus acted on consists of two parts—the one nearest the beak of the blow-pipe forming a blue obscure cone, the other external to this being of a shining yellow or reddish-yellow colour. The blue cone consists of the inflammable gases not yet fully incandescent, and the greatest heat is just beyond its point, where this is fully effected. The blue flame still needs oxygen for its support, and consequently tends to withdraw

it from any body placed within its influence, and is named the reducing flame. At the extremity of the yellow cone, on the other hand, the whole gases being consumed and the external air having free access, bodies are combined with oxygen, and this part is named the oxidating flame. Their action being so distinct, it is of great importance for the student to learn to distinguish accurately these two portions of the flame. This is best done by experimenting on a piece of metallic tin, which can only be kept pure in a good reducing flame, and acquires a white crust when acted on by the oxidating flame.

The portion of the mineral to be examined should not be larger than a peppercorn, or a fine splinter a line or two long. It is supported in the flame either by a pair of fine pincers pointed with platinum, or on slips of platinum-foil, or on charcoal. Platinum is best for the siliceous minerals, whereas for metallic substances charcoal must be employed. For this purpose solid uniform pieces are chosen, and a small cavity formed in the surface in which the mineral to be tested can be deposited.

In examining a mineral by heat, it should be first tested alone, and then with various reagents. When placed alone in a matrass or tube of glass closed at one end, and heated over a spirit lamp, water or other volatile ingredients, mercury, arsenic, tellurium, often sulphur, may readily be detected, being deposited in the cooler part of the tube, or, like fluorine, acting on the glass. It may next be tried in an open tube of glass, through which a more or less strong current of air passes according to the inclination at which the tube is held, so that volatile oxides or acids may be formed; and in this way the chief combinations of sulphur, selenium, tellurium, and arsenic are detected. On charcoal, in the reducing flame, arsenic, and in the oxidating flame, selenium or sulphur, are shown by their peculiar odour; antimony, zinc, lead, and bismuth leave a mark or coloured ring on the charcoal; and other oxides and sul-

phurets are reduced to the pure metal. On charcoal or in the platinum pincers the fusibility of minerals is tested, and some other phenomena should be observed—as whether they intumesce (bubble up), effervesce, give out fumes, become shining, or impart a colour to the flame. The colour is seen when the assay is heated at the point of the inner flame, and is—

Reddish-yellow, from soda and its salts;
Violet, from potash and most of its salts;
Red, from lithia, strontia, and lime;
Green, from baryta, phosphoric acid, boracic acid, molybdic acid, copper oxide, and tellurium oxide;
Blue, from chloride of copper, bromide of copper, selenium, arsenic, antimony, and lead.

The fusibility, or ease with which a mineral is melted, should also be observed; and to render this character more precise, von Kobell has proposed this scale:—(1.) Antimony glance, which melts readily in the mere candle flame; (2.) Natrolite, which in fine needles also melts in the candle flame, and in large pieces readily before the blowpipe; (3.) Almandine (garnet from Zillerthal), which does not melt in the candle flame even in fine splinters, but in large pieces before the blowpipe; (4.) Strahlstein (hornblende from Zillerthal) melts with some difficulty, but still more readily than (5.) Orthoclase (or adularia felspar); and (6.) Bronzite or diallage, of which only the finest fibres can be rounded by the blowpipe. In employing this scale, fine fragments of the test minerals and of that to be tried, and nearly of equal size, should be exposed at the same time to the flame. A more common mode of expressing fusibility is to state whether it is observable in large or small grains, in fine splinters, or only on sharp angles. The result or product of fusion also yields important characters, being sometimes a glass, clear, opaque, or coloured; at other times an enamel, or a mere slag.

The most important reagents for testing minerals with

the blowpipe are the following:—(1.) Soda (the carbonate), acting as a flux for quartz and many silicates, and especially for reducing the metallic oxides. For the latter purpose, the assay (or mineral to be tried) is reduced to powder, kneaded up with moist soda into a small ball, and placed in a cavity of the charcoal. Very often both the soda and assay sink into the charcoal, but by continuing the operation they either again appear on the surface, or, when it is completed, the charcoal containing the mass is finely pounded and washed away with water, when the reduced metal is found in the bottom of the vessel. (2.) Borax (biborate of soda) serves as a flux for many minerals, which are best fused in small splinters on platina wire. The borax when first exposed to the flame swells up or intumesces greatly, and it should therefore be first melted into a small bead, in which the assay is placed. During the process the student should observe whether the assay melts easily or difficultly, with or without effervescence, what colour it imparts to the product both when warm and when cold, and also the effect both of the oxidating and reducing flames. (3.) Microcosmic salt, or salt of phosphorus (phosphate of soda and ammonia) is specially important as a test for metallic oxides, which exhibit far more decided colours with it than with borax. It is also a useful reagent for many silicates, whose silica is separated from the base and remains undissolved in the melted salt. (4.) Solution of cobalt (nitrate of cobalt dissolved in water), or dry oxalate of cobalt, serve as tests of alumina, magnesia, and zinc oxide.

In examining minerals in the moist way, the first point to be considered is their solubility, of which three degrees may be noted: (1) minerals soluble in water; (2) minerals soluble in hydrochloric or nitric acid; and (3) those unaffected by any of these fluids. The minerals soluble in water are either acids (almost only the boracic acid or sassolin and the arsenious acid), or oxygen or haloid salts. These are easily tested, one part of the solution being em-

ployed to find the electro-positive element or basis, the other the electro-negative or acid.

Minerals insoluble in water may next be tested with the above acids; the nitric acid being preferable when it is probable, from the aspect of the mineral or its conduct before the blowpipe, that it contains an alloy, a sulphuret, or arseniate of some metal. In this manner the carbonic, phosphoric, arsenic, and chromic acid salts, many hydrous and anhydrous silicates, many sulphurets, arseniates, and other metallic compounds, are dissolved, so that further tests may be employed.

The minerals insoluble either in water or these acids are sulphur, graphite, cinnabar, some metallic oxides, some sulphates, and compounds with chlorine and fluorine, and especially quartz, and various silicates. For many of these no test is required, or those furnished by the blowpipe are sufficient. The silicates and others may be fused with four times their weight of anhydrous carbonate of soda when they are rendered soluble, so that further tests may be applied.

Chemical Reaction of the more Important Elements.

It is not intended in this place to describe the chemical nature of the elementary substances, and still less to enumerate the whole of those marks by which the chemist can detect their presence. Our object is limited principally to the conduct of minerals before the blowpipe, and to a few simple tests by which their more important constituents may be discovered by the student.

I.—NON-METALLIC ELEMENTS, AND THEIR COMBINATIONS WITH OXYGEN.

Nitric Acid.—Most of its salts detonate when heated on charcoal. In the closed tube they form nitrous acid, easily

known by its orange colour and smell; a test more clearly exhibited when the salt is mixed with copper filings and treated with concentrated sulphuric acid. When to the solution of a nitrate, a fourth part of sulphuric acid is added, and a fragment of green vitriol placed in it, the surrounding fluid becomes of a dark-brown colour.

Sulphur and its compounds, in the glass tube or on charcoal, form sulphurous acid, easily known by its smell. The minutest amount of sulphur or sulphuric acid may be detected by melting the pulverized assay with two parts soda and one part borax, and placing the bead moistened with water on a plate of clean silver, which is then stained brown or black. Solutions of sulphuric acid give with chloride of barium a heavy white precipitate, insoluble in acids.

Phosphoric Acid.—Most combinations with this acid tinge the blowpipe flame green, especially if previously moistened with sulphuric acid. The experiment must be performed in the dark, when even three per cent. of the acid may be detected. If the assay is melted with six parts of soda, digested in water, filtered, and neutralized with acetic acid, the solution forms an orange-yellow layer round a crystal of nitrate of silver. This solution, with muriate of magnesia, forms a white crystalline precipitate.

Selenium and *Selenic Acid* are readily detected by the strong smell of decayed horse-radish, and leave a gray deposit with a metallic lustre on the charcoal.

Chlorine and its salts. When oxide of copper is melted with salt of phosphorus into a very dark-green bead, and an assay containing chlorine fused with this, the flame is tinged of a beautiful reddish blue colour, till all the chlorine is driven off. If very little chlorine is present, the assay is dissolved in nitric acid (if not soluble it must first be melted with soda on platinum wire), and the diluted solution gives, with nitrate of silver, a precipitate of chloride of silver, which is first white, but on exposure to the light becomes gradually brown, and at length black.

Iodine and its salts, treated like chlorine, impart a very beautiful bright-green colour to the flame; and heated in the closed tube with sulphate of potash, yield violet-coloured vapours. In solution it gives, with nitrate of silver, a precipitate similar to chlorine, but which is very difficultly soluble in ammonia. Its surest test is the blue colour it imparts to starch, best seen by pouring concentrated sulphuric acid over the mineral in a test tube which has a piece of paper or cotton covered with moist starch over its mouth.

Bromine and its salts, treated in the same manner with salt of phosphorus and oxide of copper, colour the blowpipe flame greenish-blue. In the closed tube with nitrate of potassa they yield bromine vapours, known by their yellow colour and peculiar disagreeable smell. Treated with sulphuric acid, bromine in a few hours colours starch pomegranate-yellow.

Fluorine is shown by heating the assay with sulphate of potassa, in a closed tube with a strip of logwood paper in the open end. The paper becomes straw-yellow, and the glass is corroded. Another test is to heat the pulverized mineral with concentrated sulphuric acid in a shallow dish of platinum (or lead), over which a plate of glass covered with a coat of wax, through which lines have been drawn with a piece of sharp-pointed wood, is placed. If fluorine is present the glass is etched where exposed.

Boracic Acid.—The mineral alone, or moistened with sulphuric acid, when melting colours the flame momentarily green. If the assay be heated with sulphuric acid, and alcohol added and set on fire, the flame is coloured green from the vapours of the boracic acid.

Carbon, pulverized and heated with saltpetre, detonates, leaving carbonate of potassa. Carbonic acid is not easily discovered with the blowpipe, but the minerals containing it effervesce in hydrochloric acid, and the colourless gas that escapes renders litmus paper red. In solution it forms

a precipitate with lime-water, which is again dissolved with effervescence in acids.

Silica, before the blowpipe, alone is unchanged; is very slowly acted on by borax, very little by salt of phosphorus, but with soda melts entirely with a brisk effervescence into a clear glass. The silicates are decomposed by salt of phosphorus, the silica being left in the bead as a powder or a skeleton. Most of them melt with soda to a transparent glass. Some silicates are dissolved in hydrochloric acid, and this the more readily the more powerful the basis, the less proportion of silica, and the greater the amount of water they contain. Sometimes the acid only extracts the basis, leaving the silica as a powder or jelly; or the silica too is dissolved, and only gelatinizes on evaporation. The insoluble silicates may be first melted with some carbonate of an alkali, when the solution gelatinizes, and finally leaves a dry residuum of which the part insoluble in warm hydrochloric acid has all the properties of silica.

II.—THE ALKALIES AND EARTHS.

Ammonia, heated with soda in a closed tube, is readily known by its smell. Its salts, heated with solution of potassa, also yield the vapour, known from its smell, its action on turmeric paper, and the white fumes that rise from a glass tube dipped in hydrochloric acid held over it.

Soda imparts a reddish-yellow colour to the external flame when the assay is fused or kept at a strong red heat. In solution it yields no precipitate with chloride of platinum or sulphate of alumina.

Lithia is best recognised by the beautiful carmine-red colour it imparts to the flame during the fusion of a mineral containing it in considerable amount. Where the proportion is small, the colour appears if the assay be mixed with 1 part fluor spar and 1½ parts sulphate of potassa. In

concentrated solutions it forms a precipitate with the phosphate and carbonate of soda, but none with bichloride of platinum, sulphate of alumina, or acetic acid.

Potassa gives a violet colour to the external cone, when the assay is heated at the extremity of the oxidating flame. The presence of lithia or soda, however, disturbs this reaction. It may still be discovered by melting the assay in borax glass coloured brown by nickel oxide, which is changed to blue by the potassa. In concentrated solutions of potassa the bichloride of platinum gives a citron-yellow precipitate; acetic acid a white granular precipitate; and sulphate of alumina, after some time, a deposit of alum-crystals.

Baryta.—The carbonate of this earth melts easily to a clear glass, milk-white when cold; the sulphate is very difficultly fusible. Both strongly heated at the point of the blue flame impart a green tinge to the outer flame. When combined with silica it cannot be well discovered by the blowpipe. In solution, salts of baryta yield, with sulphuric acid or solution of sulphate of lime, *immediately* a fine white precipitate insoluble in acids or alkalies.

Strontia, the carbonate, even in thin plates, only melts on the edges, and forms cauliflower-like projections of dazzling brightness; the sulphate melts easily in the oxidating flame, and in the reducing flame is changed into sulphuret of strontium, which, dissolved in hydrochloric acid, and evaporated to dryness, gives a fine carmine-red colour to the flame of alcohol. Strontia in solution gives a precipitate with sulphuric acid, or with sulphate of lime, but not *immediately*.

Lime.—The carbonate is rendered caustic by heat, when it has alkaline properties, and readily absorbs water. The sulphate in the reducing flame changes to the sulphuret of calcium, which is also alkaline. Sulphuric acid precipitates lime only from very concentrated solutions; oxalic acid even from very weak ones; and silico-hydrofluoric acid

not at all. As baryta and strontia also form precipitates with the first two reagents, they must previously be separated by sulphate of potassa. Chloride of calcium tinges the flame of alcohol yellowish-red.

Magnesia, alone, or as a hydrate, a carbonate, and in some other combinations, when ignited with solution of cobalt, or the oxalate of cobalt, assumes a light-red tint. It is not precipitated from a solution either by sulphuric acid, oxalic acid, or silico-hydrofluoric acid; but phosphoric acid, with ammonia, throws down a white crystalline precipitate of phosphate of ammonia and magnesia.

Alumina alone is infusible. In many combinations, when ignited with solution of cobalt, it assumes a fine blue colour. It is thrown down by potassa or soda as a white voluminous precipitate, which in excess of the alkali is easily and completely soluble, but is again precipitated by muriate of ammonia. Carbonate of ammonia also produces a precipitate which is not soluble in excess.

Glucina, *Yttria*, *Zirconia*, and *Thorina* are not properly distinguished by blowpipe tests, though the minerals in which they occur are well marked in this way. In solution glucina acts with potassa like alumina; but the precipitate with carbonate of ammonia is again soluble, with excess of the alkali, and the two earths may thus be separated. Yttria is precipitated by potassa, but is not again dissolved by excess of the alkali. With carbonate of ammonia it acts like glucina. It must be observed, however, that the substance formerly named yttria is now considered a mixture of this earth with the oxides of erbium, terbium, and lanthanium. Zirconia acts with potassa like yttria, and with carbonate of ammonia like glucina. Concentrated sulphate of potassa throws down a double salt of zirconia and potassa, which is very little soluble in pure water.

III.—THE METALS.

Arsenic and its sulphuret on charcoal yield fumes, with a smell like garlic, and sublime in the closed tube. The greater number of alloys of arsenic in the reducing flame leave a white deposit on the charcoal; or, where it is in larger proportion, give out grayish-white fumes with a smell of garlic. Some alloys also yield metallic arsenic in the closed tube. In the open tube all of them yield arsenious acid, and those containing sulphur also sulphurous fumes. Many arsenic acid salts emit evident odours of arsenic when heated on charcoal with soda; and some sublime metallic arsenic when heated with pulverized charcoal in the closed tube.

Antimony melts easily on charcoal, emiting dense white fumes, and leaving a ring of white crystalline oxide on the support. In the closed tube it does not sublime, but burns in the open tube with white smoke, leaving a sublimate on the glass, which is easily driven from place to place by heat. Most of its compounds, with sulphur or with the other metals, show similar reaction. Antimony oxide on charcoal melts easily, fumes, and is reduced, colouring the flame pale greenish-blue.

Bismuth melts easily, fumes, and leaves a yellow oxide on the charcoal. In the closed tube it does not sublime, and in the open tube scarcely fumes, but is surrounded by the fused oxide, dark-brown when warm, and bright-yellow when cold. Its oxides are easily reduced. A great addition of water produces a white precipitate from its solution in nitric acid.

Tellurium fumes on charcoal, and becomes surrounded by a white mark with a reddish border, which, when the reducing flame is turned on it, disappears with a bluish-green light. In the closed tube tellurium gives a sublimate of the gray metal; and in the open tube produces

copious fumes, and a white powder which can be melted into small clear drops.

Mercury in all its combinations is volatile, and yields a metallic sublimate when heated alone, or with tin or soda in the closed tube.

Zinc, when heated with soda on charcoal, forms a deposit, which, when warm, is yellow; when cold, white; is tinged of a fine green by solution of cobalt, and is not further volatile in the oxidating flame. In solution zinc is precipitated by potassa as a white gelatinous hydrate, easily redissolved in the excess of the alkali.

Tin forms a white deposit on the charcoal behind the assay, which takes a bluish-green colour with the solution of cobalt. The oxide is easily reduced by soda.

Lead forms a sulphur-yellow deposit with a white border on the charcoal when heated in the oxidating flame, and with soda is easily reduced. The solutions of its salts are colourless, but give a black precipitate with sulphuretted hydrogen; with sulphuric acid a white, and with chromate of potassa a yellow, precipitate.

Cadmium produces, with soda, a reddish-brown or orange-yellow ring, with iridescent border on the charcoal, and also on platinum-foil.

Manganese alone, melted with borax or salt of phosphorus on the platinum wire in the oxidating flame, forms a fine amethystine glass, which becomes colourless in the reducing flame. In combination with other metals, the pulverized assay mixed with two or three times as much soda, and melted in the oxidating flame on platinum-foil, forms a bluish-green glass. Potassa or ammonia throws down from solutions of its salts a white hydrate, which in the air becomes gradually dark-brown.

Cobalt, melted with borax in the oxidating flame, gives a beautiful blue glass. Minerals of metallic aspect must be first roasted on charcoal. The salts of protoxide of cobalt form bright-red solutions, from which potassa throws

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down a blue flaky hydrate, which becomes olive-green in the air.

Nickel, the assay, first roasted in the open tube and on charcoal, produces in the oxidating flame, with borax, a glass, which hot, is reddish or violet-brown; when cold, yellowish or dark red; and by the addition of saltpetre changes to blue. In the reducing flame the glass appears gray. With salt of phosphorus the reaction is similar, but the glass is almost colourless when cold. The salts in solution have a bright-green colour, and with potassa form a green precipitate of hydrated nickel-oxide, which is unchanged in the air.

Copper may in most cases be discovered by melting the assay (if apparently metallic, first roasted) with borax or salt of phosphorus in the oxidating flame, when an opaque reddish-brown glass is produced, a small addition of tin aiding in the result. In the reducing flame the glass, when warm, is green; when cold, blue. With soda metallic copper is produced. A small proportion of copper may often be detected by heating the assay, moistened with hydrochloric acid, in the oxidating flame, which is then tinged of a beautiful green colour. Solutions of its salts are blue or green, and produce a brownish-black precipitate, with sulphuretted hydrogen. Ammonia at first throws down a pale-green or blue precipitate, but in excess produces a very fine blue colour.

Silver in the metallic state is at once known, and from many combinations can be readily extracted on charcoal with soda. From its solution in nitric acid silver is thrown down by hydrochloric acid as a white chloride, which in the light soon becomes black, is soluble in ammonia, and can again be precipitated from this solution by nitric acid as chloride of silver.

Gold, when pure, is readily known, and is easily separated from its combinations with tellurium on charcoal. If the grain is white, it contains more silver than gold, and must

then be heated in a porcelain capsule with nitric acid, which gives it a black colour, and gradually removes the silver, if the gold is only a fourth part or less. If the proportion of gold is greater, the nitro-chloric acid must be used, which then removes the gold. From its solution in this acid the protochloride of tin throws down a purple precipitate *(purple of Cassius)*, and the sulphate of iron, metallic gold.

Platinum, and the metals usually found with it, cannot be separated from each other by heat. Only the *Osmium-iridium* strongly heated in the closed tube with saltpetre is decomposed, forming osmium acid, known from its peculiar pungent odour. The usual mixture of platinum grains is soluble in nitro-chloric acid, leaving osmium-iridium. From this solution the *platinum* is thrown down by sal-ammonia as a double chloride of platinum and ammonium. From the solution evaporated, and again diluted, with cyanide of mercury, the *palladium* separates as cyanide of palladium. The *rhodium* may be separated by its property of combining with fused bisulphate of potassa, which is not the case with platinum or iridium.

Cerium, when no iron-oxide is present, produces, with borax and salt of phosphorus, in the oxidating flame, a red or dark-yellow glass, which becomes very pale when cold, and colourless in the reducing flame. *Lanthanium* oxide forms a white colourless glass; *didymium* a dark amethystine glass.

Iron, the peroxide and hydrated peroxide, become black and magnetic before the blowpipe, and form, with borax or salt of phosphorus, in the oxidating flame, a dark-red glass, becoming bright-yellow when cold; and in the reducing flame, especially on adding tin, an olive-green or mountain-green glass. The peroxide colours a bead of borax containing copper oxide bluish-green; the protoxide produces red spots. Salts of protoxide of iron form a green solution, from which potassa or ammonia throws down the protoxide as a hydrate, which is first white, then dirty-green, and

finally yellowish-brown. Carbonate of lime produces no precipitate. The salts of the peroxide, on the other hand, form yellow solutions from which the peroxide is thrown down by potassa or ammonia as a flaky-brown hydrate. Carbonate of lime also causes a precipitate.

Chromium forms, with borax or salt of phosphorus, a glass, fine emerald-green when cold, though when hot often yellowish or reddish. Its solutions are usually green, and the metal is thrown down by potassa as a bluish-green hydrate, again dissolved in excess of the alkali. The chrome in many minerals is very certainly discovered by melting the assay with three times its bulk of saltpetre, which, dissolved in water, gives with acetate of lead a yellow precipitate.

Vanadium, melted on platinum wire with borax or salt of phosphorus, gives a fine green glass in the reducing flame, which becomes yellow or brown in the oxidating flame, distinguishing it from chrome.

Uranium, with salt of phosphorus, forms in the oxidating flame a clear yellow; in the reducing flame a fine green glass. With borax its reaction is similar to that of iron.

Molybdenum forms in the reducing flame, with salt of phosphorus, a green; with borax, a brown glass.

Tungsten or *Wolfram* forms, with salt of phosphorus, in the oxidating flame, a colourless or yellow; in the reducing flame, a very beautiful blue glass, which appears green when warm. When accompanied by iron the glass is blood-red, not blue. Or melt the assay with five times as much soda in a platinum spoon, dissolve it in water, filter, and decompose the result with hydrochloric acid, which throws down the tungstic acid, which is white when cold, but citron-yellow when heated.

Tantalium, as tantalic acid, is readily dissolved by salt of phosphorus, and in large quantity into a colourless glass, which does *not* become opaque in cooling, and does *not* acquire a blue colour from solution of cobalt. Or fuse the

assay with two times as much saltpetre, and three times as much soda, in a platinum spoon; dissolve this, filter, and decompose the fluid by hydrochloric acid: the tantalic acid separates as a white powder, which does *not* become yellow when heated.

Titanium in anatase, rutile, brookite, and titanite, is shown by the assay forming, with salt of phosphorus, in the oxidating flame, a glass which is and remains colourless; in the reducing flame, a glass which appears yellow when hot, and whilst cooling passes through red into a beautiful violet. When iron is present, however, the glass is blood-red, but is changed to violet by adding tin. When titanate of iron is dissolved in hydrochloric acid, and the solution boiled with a little tin, it acquires a violet colour from the oxide of titanium. Heated with concentrated sulphuric acid, the titanate of iron produces a blue colour.

CHAPTER IV.

CLASSIFICATION OF MINERALS.

A mineral species was formerly defined as a natural inorganic body, possessing a definite chemical composition and peculiar external form. The account given of these properties shows that the form of a mineral species comprehends not only the primary or fundamental figure, but all those that may be derived from it by the laws of crystallography. Irregularities of form arising from accidental causes, or that absence of form which results from the limited space in which the mineral has been produced, do not destroy the identity of the species. Even amorphous masses, when the chemical composition remains unaltered, are properly classed under the same species, as the perfect crystal.

The definite chemical composition of mineral species must be taken with equal latitude. Pure substances, such as they are described in works on chemistry, are very rare in the mineral kingdom. In the most transparent quartz crystals traces of alumina and iron oxide can be detected; the purest spinel contains a small amount of silica, and the most brilliant diamond, consumed by the solar rays, leaves some ash behind. Such non-essential mixtures must be neglected, or each individual crystal would form a distinct mineral species. The isomorphous elements introduce a wider range of varieties, and render the limitation of species more difficult. Carbonate of lime, for instance, becomes mixed with carbonate of magnesia or of iron in almost innumerable proportions; and the latter substances also with the former. Where these mixtures are small in amount, variable in different specimens, and do not greatly affect the form or physical characters of the predominant element, they may safely be neglected, and the mineral reckoned to that species with which it most closely agrees. Where, however, the mixture is greater, and the two substances are frequently found in definite chemical proportions, these compounds must be considered as distinct species, especially should they also show differences in form and other external characters.

Amorphous minerals with definite composition must also be considered as true species. But when they show no definite composition, as in many substances classed as clays and ochres, they cannot be accounted true mineral species, and properly ought not to be included in a treatise on mineralogy. Some of them, however, from their importance in the arts, others from other circumstances, have received distinct names and a kind of prescriptive right to a place in mineralogical works, from which they can now scarcely be banished. Many of them are properly rocks, or indefinite combinations of two or more minerals; others are the mere products of the decomposition of such bodies.

Their number is of course indefinite, and their introduction tends much to render mineralogy more complex and difficult, and to destroy its scientific character.

In collecting the species into higher groups, and arranging them in a system, several methods have been pursued. Some, like Mohs, have looked only at the external characters, and asserted that they alone were sufficient for all the purposes of arranging and classifying minerals. Others, led by Berzelius, have, on the contrary, taken chemistry as the foundation of mineralogy, and classed the species by their composition, without reference to form or physical characters.

Neither system can be exclusively adopted, and a natural classification of minerals should take into account all their characters, and that in proportion to their relative importance. Among these the chemical composition undoubtedly holds a high rank, as being that on which the other properties will probably be ultimately found to depend. Next in order is their crystalline form, especially as exhibited in cleavage; and then their other characters of gravity, hardness, and tenacity. But the properties of minerals are as yet far from showing that subordination and co-relation which has been observed in the organic world, where the external forms and structures have a direct reference to the functions of the living being. Hence, even when all the characters are taken into account, there is not that facility in classifying the mineral that is presented by the other kingdoms of nature. Many, or rather most, of the species stand so isolated that it is scarcely possible to find any general principle on which to collect them into larger groups, especially such groups as, like the natural families of plants and animals, present important features of general resemblance, and admit of being described by common characteristics. Certain groups of species are indeed united by such evident characters, that they are found together in almost every method; but other species

are not thus united, and the general order of arrangement is very uncertain. Hence, though some classifications of very considerable merit have been proposed, no natural system of minerals commanding general assent has yet appeared.

The arrangement followed in this treatise is chiefly founded on that proposed by Professor Weiss of Berlin. We have, however, made considerable changes, which the progress of the science and the more accurate knowledge of many species require. This classification appears to us to come nearer than any other we have seen to a natural system, which in arranging and combining objects takes account of all their characters, and assigns them their place, from a due consideration of their whole nature, and is thus distinguished from artificial systems, which classify objects with reference only to one character.

Besides species, two higher grades in classification seem sufficient at once to exhibit the natural relations, and to facilitate an easy and complete review of the species composing the mineral kingdom. These are families and orders. In forming the families those minerals are first selected which occupy the more important place in the composition of rocks, and consequently in the crust of the globe. Thus quartz, felspar, mica, hornblende, garnet, among siliceous minerals; calc-spar, gypsum, rock-salt, less so fluor spar and heavy spar, among those of saline composition, stand out prominently as the natural centres or representatives of so many distinct families. To these certain metallic minerals, as iron pyrites, lead-glance or galena, blende, magnetic iron ore, the sparry iron ore, and a few more, are readily associated as important families. But the minerals thus geologically distinguished are not sufficient to divide the whole mineral kingdom into convenient sections, and additional groups must be selected from the peculiarity of their natural-historical or chemical properties. Thus the zeolites are easily seen to form such a natural group. The

precious stones or gems also, notwithstanding their diverse chemical composition, must ever appear a highly natural family, when regarded as individual objects. Their great hardness, tenacity, high specific gravity without the metallic aspect, their brilliant lustre, transparent purity, and vivid colours,—all mark them out as a peculiar group. Only the diamond, which might naturally seem to take the chief place in this class, differs so much, not only in elementary composition, but in physical properties, that it must be assigned to a diverse place.

Round these species thus selected the other less important minerals are arranged in groups or families. It is evident that no precise definition of these families can be given, as the connection is one of resemblance in many points, not of identity in any single character. In other words, it is a classification rather according to types than from definitions, as every true natural classification must be. The same cause, however, leaves the extent of the families somewhat undefined, and also permits considerable license in the arrangement of species. But both circumstances are rather of advantage in the present state of the science, as allowing more freedom in the grouping of species than could be obtained in a more rigid system of classification.

In collecting the families into orders, the guidance of chemistry is followed rather than of natural history, though the latter is also taken into consideration. Chemical names are assigned to the orders, but still regarded *as names* derived from the prevailing chemical characters, and *not as definitions.* Hence it must not be considered an error should two or three mineral species be found in an order with whose name, viewed as a definition, they may not agree.

Guided by these, and similar considerations, minerals may be divided into the following orders and families :—

ORDER I.—THE OXIDIZED STONES.

Families:—1. Quartz.
2. Felspar.
3. Scapolite.
4. Haloid stones.
5. Leucite.
6. Zeolite.
7. Mica.
8. Serpentine.
9. Hornblende.
10. Clays.
11. Garnet.
12. Cyanite.
13. Gems.
14. Metallic stones.

ORDER II.—SALINE STONES.

Families:—1. Calc spar.
2. Fluor spar.
3. Heavy spar.
4. Gypsum.
5. Rock salt.

ORDER III.—SALINE ORES.

Families:—1. Sparry iron ores.
2. Iron salts.
3. Copper salts.
4. Lead salts.

ORDER IV.—OXIDIZED ORES.

Families:—1. Iron ores.
2. Tinstone.
3. Manganese ores.
4. Red copper ores.
5. White antimony ores.

ORDER V.—NATIVE METALS.

Form only one family.

ORDER VI.—SULPHURETTED METALS.

Families:—1. Iron pyrites.
2. Galena.
3. Gray antimony ore.
4. Gray copper ore.
5. Blende.
6. Ruby-blende.

ORDER VII.—THE INFLAMMABLES.

Families:—1. Sulphur.
2. Diamond.
3. Coal.
4. Mineral resins.
5. Combustible salts.

In describing the species we have followed this general plan. First, that name which it seems most expedient to adopt is given, with the principal synonyms, followed in the same line by the probable chemical formula. In these, silica

is commonly assumed as $\dot{S}i$; but we have given also the formula with $\ddot{S}i$ for the more important species. In the descriptions the system of crystallization is noted, and the mineral more precisely characterized, by enumerating some of its more common forms and combinations with their characteristic angles. The physical characters of the species, its state of aggregation, cleavage, fracture, hardness (H.), and specific gravity (G.), follow; then its lustre, pellucidity, colour, and any other marked peculiarities. Next come its chemical characters, or its conduct before the blowpipe (B.B.), and the effect of acids, specially the hydrochloric (*h.*), nitric (*n.*), and sulphuric (*s.*). The chemical composition, or the amount of the different elements in 100 parts, generally deduced from the formula, but with notices of the more important variations indicated by the best analyses either from the substitution of isomorphous elements or other substances, are then noted. The principal localities where each species occurs, especially in our own country, with certain miscellaneous particulars, conclude the description.

We have also given similar characters of the orders and families, so far as this was possible. These, of course, apply chiefly to the more important and better-marked or typical species (indicated by one or two asterisks [* or * *] prefixed to the name), but in many points are also descriptive of the others. The possibility of forming such general characters is the best proof that the groups are so far natural, and that the object of a scientific classification has been partially at least attained.

PART II.

DESCRIPTION OF MINERAL SPECIES.

ORDER I.

THE OXIDIZED STONES.

The minerals contained in this order are either simple oxides, or compounds of oxides. Oxides of the true metals are not abundant, and occur generally as isomorphous with, or replacing, the earths and alkalies which compose the greater number. They have all a stony character, non-metallic lustre and colours, and are often white and more or less translucent, except the family of the Metallic Stones, which forms a transition group to the following order.

** Family I.—Quartz.

Contains only one true species, and hence no general characteristic. Quartz is the true type or representative of the mineral kingdom.

**1.—Quartz.—$\dot{S}i$, *or* $\dddot{S}i$.

Hexagonal; the purest varieties tetartohedral. The primary pyramid P has the middle edge = 103° 34′, and the polar edges = 133° 44′, and is often perfect. Very frequently it appears as a rhombohedron R (or $\frac{1}{4}$ P), with polar edges = 94° 15′. Crystals often of ∞P . P; ∞P . P . 4P, the forms ∞P and 4P being combined in an oscillatory manner, producing striæ on the face of the

prism; $\infty P . P . \frac{1}{4}(2\,P\,2)$ (fig. 101), the last face appearing as a rhomb replacing the angles between the two other forms. They are prismatic, or pyramidal, or rhombohedric when P is divided into R and −R; the latter very often wanting.

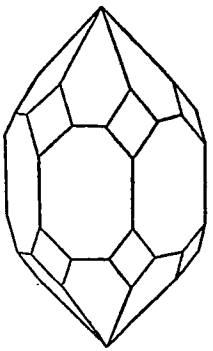


Fig. 101.

Twins or macles common, with parallel axes, and either merely in juxtaposition (see fig. 80), or interpenetrating. The crystals occur either single, attached, or imbedded, or in groups and druses. Most frequently granular, massive, fibrous, or columnar; also in pseudomorphs, petrifactions, and other forms. Cleavage, rhombohedric along R very imperfect; prismatic along ∞P still more imperfect. Fracture conchoidal, uneven, or splintery. H = 7; G = 2·5...2·8, or 2·65 in the purest varieties. Colourless, but more often white, gray, yellow, brown, red, blue, green, or even black. Lustre vitreous, inclining to resinous; transparent or translucent, sometimes almost opaque. B.B. infusible alone; with soda effervesces and melts into a clear glass; insoluble in acids, except the fluoric; when pulverized, slightly soluble in solution of potash. Chem. com. 48·04 silicium and 51·96 oxygen, but frequently a small amount of the oxides of iron or titanium, of lime, alumina, and other substances.

Varieties are,—*Rock-crystal*, highly transparent and colourless; Dauphiné, Switzerland, Tyrol, Hungary, Madagascar, and Ceylon. *Amethyst*, violet-blue (from iron peroxide or manganese), and often marked by zig-zag or undulating lines, and the colour disposed in clouds; Siberia, Persia, India, Ceylon, Brazil (white or yellow named *Topaz*), Hungary, Siebenburg, Ireland (near Cork), and Aberdeenshire. Wine yellow, or *citrin* and *gold topaz*; the brown

or *smoky quartz*; and the black or *morion*; Siberia, Bohemia, Pennsylvania, and other places. *Cairngorm stone*, brown or yellow; Aberdeenshire mountains. The above are valued as ornamental stones; less so:—

Rose-quartz, red inclining to violet-blue; Ben Macdhui, and Rabenstein in Bavaria. *Milk-quartz*, milk-white and slightly opalescent; Greenland. *Prase*, leek, and other shades of green; Saxony and Cedar Mountain in South Africa. *Cat's-eye*, greenish-white or gray, olive-green, red, brown, or yellow; Ceylon and Malabar. *Avanturine*, yellow, red, or brown; India, Spain, and Scotland. *Siderite*, indigo or Berlin blue; Golling in Salzburg.

Common quartz, crystallized or massive, white or gray, also red, brown, &c., is a frequent constituent in many rocks. Some varieties are so impure as to be properly rocks, as—

(1.) *Ferruginous quartz*, or *iron-flint*, red, yellow, or brown, often associated with iron ores.

(2.) *Jasper*, red, yellow, or brown, but also green, gray, white, and black alone, or in spots, veins, and bands (*Ribbon* or *Egyptian jasper*); the Ural, Tuscan Apennines, the Harz, and many parts of Scotland.

(3.) *Lydian stone*, or *flinty slate*, black, gray, or white; has a splintery or conchoidal fracture, breaks into irregular fragments, and passes by many transitions into clay slate, of which it is often merely an altered portion, as in Scotland; used as a touchstone for gold, and at Elfdal manufactured into ornaments.

(4.) *Hornstone* or *chert*, compact, conchoidal splintery fracture; translucent on the edges, and dirty gray, red, yellow, green, or brown; passes into flint, flinty slate, or common quartz; common in the mountain limestone, oolite, and greensand formations; and often contains petrifactions, as shells, madrepores, and wood.

Other siliceous minerals seem intermediate between quartz and opal, as,—*Flint*, grayish-white, gray, or grayish-black, also yellow, red, or brown; sometimes in clouds, spots,

or stripes; semitransparent; lustre dull; fracture flat conchoidal; occurs chiefly in the chalk formation of England, North Ireland, Aberdeenshire, France, Germany, and other countries; sometimes in beds or vertical veins, oftener in irregular lumps or concretions, inclosing petrifactions, as sponges, echinites, shells, or siliceous infusoria. The colour is partly derived from carbon or organic matter. It is used for gun-flints, and for the manufacture of glass and pottery, and cut into cameos or other ornaments.

Calcedony, semitransparent or translucent; white, gray, blue, green, yellow, or brown; stalactitic, reniform, or botryoidal, and in pseudomorphs or petrifactions; Trevascus mine in Cornwall, Scotland, Hungary, Tyrol, Bohemia, Oberstein. *Carnelian*, chiefly blood-red, but also yellow, brown, or almost black; India, Arabia, Surinam, and Siberia; also Bohemia, Saxony, and Scotland (Perthshire). *Plasma*, leek or grass-green, and waxy lustre; Olympus, Schwarzwald, India, and China. *Chrysoprase*, apple-green; Silesia, and Vermont in North America. *Heliotrope* or *bloodstone*, dark-green, sprinkled with deep-red spots; Siberia, Bohemia, the Fassa Valley, the Island of Rum and other parts of Scotland. *Agates*, mixtures chiefly of calcedony in layers, with jasper, amethyst, or common quartz, abound in the amygdaloids of our own and other countries. *Onyx*, alternate layers of white, brown, or black, was much used in ancient times for cameos.

Some crystals are remarkable for their great size, as one in the Museum at Paris, measuring 3 feet in diameter, and weighing nearly 8 cwt. Other specimens contain cavities inclosing various substances, more than 24 known, as silver, iron pyrites, rutile, magnetite, tremolite, amianthus, mica, tourmaline, topaz; also air, water, naphtha, or other fluids.

*2. Opal.—$\ddot{S}i$, $\dot{H}$.

Amorphous; fracture conchoidal; very brittle. H. $=5{\cdot}5 \ldots 6{\cdot}5$; G. $=2 \ldots 2{\cdot}2$. Transparent to opaque; vitreous,

inclining to resinous. Colourless, but often white, yellow, red, brown, green, or gray, with a beautiful play of colours. B.B. decrepitates and becomes opaque, but is infusible; in the closed tube yields water; almost wholly soluble in solution of potash. Chem. com. silica, with 5 to 13 per cent. water; or probably a mere hardened natural gelatine of silica with water as an accidental mixture.

Varieties are,—(1.) *Hyalite, glassy-opal*, or *Muller's glass*, transparent, colourless, very glassy; small botryoidal or incrusting; Frankfort-on-the-Maine, Kaiserstuhl in the Breisgau, Schemnitz in Hungary, in Silesia, Moravia, Mexico, and other places. (2.) *Fire-opal* or *girasol*, transparent, brilliant vitreous lustre; bright hyacinth red or yellow; Zimapan in Mexico, and the Faroe Islands. (3.) *Noble opal*, semitransparent or translucent; resinous inclining to vitreous; bluish or yellowish-white, with brilliant prismatic colours; in irregular masses or veins at Czernewitza near Eperies in Hungary, Frankfort, and Gracios a Dios in Honduras. (4.) *Common opal*, semitransparent, vitreous; white, yellow, green, red, or brown; Hungary, also Faroe, Iceland, the Giant's Causeway, and the Western Isles of Scotland. (5.) *Semi-opal*, duller and less pellucid. *Wood-opal* or *lithoxylon*, with the form and texture of wood distinctly seen; Hungary, also Bohemia, and near Hobart's Town in Tasmania. (6.) *Menilite*, compact, reniform; opaque and brown or bluish-gray; Mont Menil near Paris. (7.) *Opal jaspar*, blood-red, brown, or yellow. (8.) *Cacholong*, opaque, dull, glimmering, or pearly, and yellowish or rarely reddish-white; in veins or reniform and incrusting; Faroe, Iceland, the Giant's Causeway, and in Bucharia. One variety is named *Hydrophane*, from imbibing water and becoming translucent. (9.) *Siliceous sinter*, deposited from the Geyser and other hot springs near volcanoes; and *Pearl sinter*, incrusting volcanic tufa at Santa Fiora in Tuscany (*Fiorite*), in Italy, and in Auvergne. That from the Geyser contains 84·4 silica, 3·1 alumina, 1·9 peroxide of

iron, 1·1 magnesia, 0·7 lime, 0·9 potash and soda, and 7·9 water.

2 *b.* EARTHY SILICA.—(*a.*) *Spongiform quartz*, coarse earthy, soft and often friable, and yellow or grayish-white; porous, and swims on water till saturated; St Ouen near Paris. (*b.*) *Tripoli*, coarse or fine earthy; white, gray, or yellow; near Tripoli in Africa, Corfu, Bohemia, Saxony, and Bavaria. (*c.*) *Polishing slate* (*Polirschiefer*), white or yellow; slaty texture, opaque, brittle, and swims on water; at Bilin in Bohemia; consists of the siliceous remains of animals or plants (*Diatomaceæ*). (*d.*) *Adhesive slate*, from Montmartre near Paris; and (*e.*) *Mountain meal*, snow-white, pearly, gray, or greenish; have a similar origin; Santa Fiora in Tuscany, Oberohe in Hanover, Kymmenegard in Sweden (where used as food), in Bohemia, and the Isle of France.

** FAMILY II.—FELSPAR.

Crystallization monoclinohedric or triclinohedric, both very similar in aspect and angles. Cleavage very distinct, especially the basal *P*; less so the clino- or brachy-diagonal *M*. G.=2·4...3·2, but mostly 2·5...2·8; H.=6, or a little more. Slightly or not at all soluble in acids. B.B. fusible, but often with difficulty. Translucent, pure varieties highly transparent. Colourless, white, or shades of red; less common, green or yellow. Chem. com. anhydrous silicates of alumina, and of an alkali or lime.

The felspars are very important constituents of the earth's crust, occurring in nearly all the igneous rocks, and in many of the stratified crystalline schists. In true strata, they are found chiefly as fragments or decomposed, and in the latter state form a large part of most soils and clays. In the older mineralogists and popular language many species are conjoined under the common name of felspar, which are now considered as distinct, each of them having not only its peculiar physical and chemical characters, but also geog-

nostic position and associated group of minerals. Thus orthoclase, and the other more siliceous felspars with potash, abound in granite and the plutonic rocks; the less siliceous, with soda and lime, characterize the volcanic rocks—as labradorite the basaltic group, glassy felspar the trachytic. Orthoclase occurs with quartz, hornblende, and mica; glassy felspar only with hornblende and mica, or only with augite; labradorite only with augite, rarely if ever with quartz or hornblende.

The felspars are best known from similar minerals by their hardness (scarce scratch with a good knife), difficult fusibility, and unequal cleavages. The following marks may aid the student in distinguishing the more common species. If the basal cleavage plane is turned to the spectator, then in orthoclase it forms a right angle with the clinodiagonal cleavage planes *M* on both hands; in albite, oligoclase, and petalite it forms an obtuse angle with *M* on his right hand; and in labradorite and anorthite on his left hand. Orthoclase, albite, andesin, and oligoclase are insoluble in acids; ryacolite, labradorite, and anorthite more or less soluble.

S. von Waltershausen states that the felspars form a series with the oxygen of the silica, alumina, and $\dot{R} = x : 3 : 1$, in which x ranges from 24 to 4. Baulite (with 80 silica), albite (69 silica), and anorthite (44 silica), being the three true species, of which the others are mixtures, according to a peculiar law (isomorphism of groups).

** 3. ORTHOCLASE.—$\ddot{\dot{A}}l\ \ddot{S}i^3 + \dot{K}\ \ddot{S}i^3$, *or* $\ddot{\dot{A}}l\ \ddot{S}i^3 + \dot{K}\ \ddot{S}i$.

Monoclinohedric; C = 65° 47′, ∞P 118° 50′, P∞ 63° 53′, (2P∞) 90°, 2P∞ 35° 12′. Crystals often of ∞P . 0P . P∞; or (∞P∞) (*M*) . ∞P (*T*, *l*) . 0P (*P*) . 2 P∞ (*y*), (fig. 102), are short rhombic prisms, when ∞P predominates; or tabular when (∞P∞); or short hexagonal prismatic when ∞P and (∞P∞); or rectangular prismatic when 0P and (∞P∞) predominate; and occur single, attached, or in druses. Macles are frequent, especially with the twin

axis parallel to the chief axis, and often partially interpenetrating as in fig. 103; also massive and coarse or fine

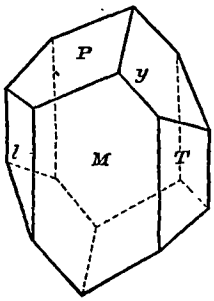


Fig. 102.

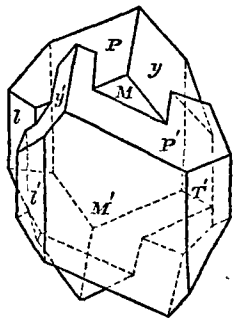


Fig. 103.

granular. Cleavage, basal (*P*) very perfect; clinodiagonal (*M*) perfect (*P* to *M* = 90°); and hemiprismatic ∞P in traces. Fracture conchoidal or uneven and splintery. H. = 6; G. = 2·53...2·58. Transparent to translucent on the edges; vitreous, but often pearly on the more perfect cleavage; and also opalescent, with bluish or changing colours. Colourless, but generally red, yellow, gray, or green. B.B. fuses with difficulty to an opaque vesicular glass; not affected by acids. Chem. com. 65·4 silica, 18 alumina, and 16·6 potash, but generally 10 to 14 potash, 1 to 4 soda, 0 to 1·3 lime, 0 to 2 iron peroxide.

Varieties are,—(1.) *Adularia* and *Ice-spar*, transparent or translucent, splendent, and almost or wholly colourless. Some with a bluish opalescence are named *Moonstone;* St Gotthardt, Mont Blanc, Dauphiné, Arendal, Southern Norway, Greenland, and Ceylon.

(2.) *Common felspar*, less splendent and transparent, and generally white or red, especially flesh-red, is a very common constituent of many rocks. Crystals at Baveno on Lago Maggiore, Lomnitz in Silesia, Mourne Mountains and Wicklow in Ireland, Aberdeenshire (at Rubislaw, 4 or 5 inches long) in Scotland, and at Carlsbad and Elnbogen in Bohemia. *Amazon stone*, verdigris-green, from

Lake Ilmen; and *Murchisonite*, golden or grayish-yellow, from Arran and Dawlish, seem varieties.

(3.) The *Glassy felspar* or *sanadine* (C = 63° 55', ∞ P 119° 13'), contains 3 to 12 potash, 3 to 10 soda, 0 to 3 lime, and 0 to 2 magnesia. Crystals imbedded, yellowish-white or gray; vitreous; transparent or translucent, and often much cracked;

Macles of common Felspar.

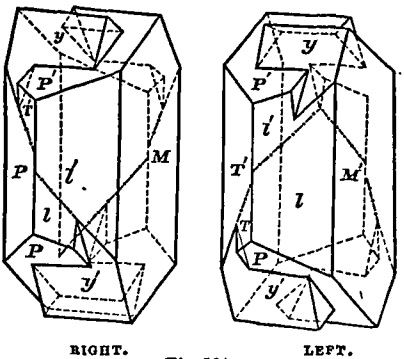


Fig. 104.

Drachenfels on the Rhine, Mont d'Or and other parts of Auvergne, Hungary, Italy, Iceland, Mexico, Chili, and other countries; also in Arran, Rum, and other parts of Scotland. *Ryacolite*, from Vesuvius and Lake Laach, is only a variety—the specimen analysed having been impure. *Loxoclase*, from Hammond, New York, also a variety with much soda. *Baulite* and *Krablite* from Iceland, probably mixtures with quartz.

Orthoclase occurs in granite, gneiss, and porphyry in many countries. It is commonly associated with quartz, sometimes, as in the graphic granite of Portsoy and Aberdeenshire, in regular combinations. It is very liable to decomposition, when it is converted especially into kaolin, used for manufacturing porcelain and stoneware. The adularia or moonstone, and the green amazon stone are cut as ornamental stones.

Compact felspar, or *feldstein*, a mixture of orthoclase and quartz, often harder than the pure mineral. G.=2·59 ...3. White, gray, red, or yellow, sometimes in spots or bands. The softer varieties, or *claystones*, often bluish or purplish. G.=2·21. B.B. most melt with difficulty to a white enamel (hornstone is infusible). Common in the porphyry rocks of many countries, as in Scotland (Cheviots, Pentland, and Ochil Hills), and Sweden (*leelite* from Grythyttan).

** 4. ALBITE.—$\dddot{\mathrm{A}}\mathrm{l}\,\ddot{\mathrm{S}}\mathrm{i}^3 + \dot{\mathrm{N}}\mathrm{a}\,\ddot{\mathrm{S}}\mathrm{i}^3$, *or* $\dddot{\mathrm{A}}\mathrm{l}\,\dddot{\mathrm{S}}\mathrm{i}^3 + \dot{\mathrm{N}}\mathrm{a}\,\dddot{\mathrm{S}}\mathrm{i}$.

Triclinohedric; 0P (*P*) to $\infty\breve{\mathrm{P}}\infty$ (*M*) = 86° 24′, $\infty\mathrm{P}'$

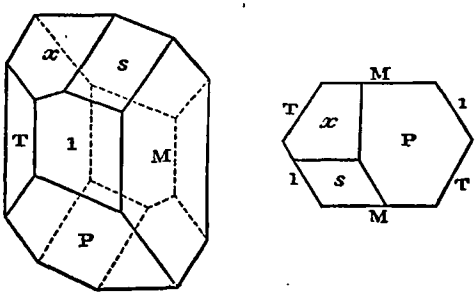


Fig. 105.

(*l*) to ∞'P (*T*) = 122° 15′. Crystals, generally like those of orthoclase, are tabular or prismatic (fig. 105). Macles very

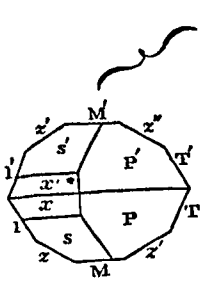
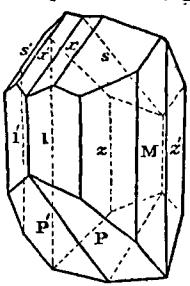


Fig. 106.



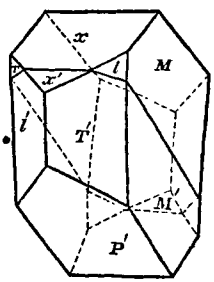


Fig. 107.

common, especially united by a face of $\infty\breve{\mathrm{P}}\infty$ (fig. 106), the re-entering angle between the faces of 0P (*P* and *P'*

= 172° 48′) being very characteristic. Fig. 107 is another macle common in pericline. Also massive and foliated or radiating. Cleavage, basal and brachydiagonal almost equally perfect, prismatic along ∞P imperfect; fracture conchoidal or uneven. H. = 6...6·5; G. = 2·6...2·67. Rarely transparent, usually translucent or only on the edges; vitreous, inclining to pearly on the cleavage. Colourless, but generally white, gray, green, red, or yellow; streak white. B.B. difficultly fusible, tinging the flame yellow, to a white semi-opaque glass; not affected by acids. Chem. com. 69·3 silica, 19·1 alumina with 0·1 to 1 iron peroxide and 11·6 soda with 0·3 to 4 lime, 0 to 2·5 potash, and 0 to 0·5 magnesia. Hence albite and orthoclase both contain soda and potash, only in different proportions. Albite is best marked by the frequent re-entering angles, its more easy fusibility, and the obliquity (93° 36′) of its cleavage planes. *Pericline*, with G. = 2·54...2·6, and slight diversity in angles, is only a variety.

Albite is a constituent of many greenstones (Edinburgh), of granite (Aberdeenshire), syenite, gneiss, porphyry, and trachyte; also in beds and veins; crystals at Barèges in the Pyrenees, Bourg d'Oisans in Dauphiné, St Gotthardt, the Tyrol, Salzburg, and Arendal. *Adinole* is a compact gray or red mixture of albite and quartz.

5. ANDESIN.—$\dddot{Al}\ \ddot{Si}^2 + (\dot{Na}, \dot{Ca})\ \ddot{Si}$.

Triclinohedric; crystals and physical properties similar to albite, but the cleavage less distinct. G. = 2·67...2·73. B.B. more easily fusible (like oligoclase) to a milky somewhat porous glass. Chem. com. 60 silica, 25 alumina, 7 soda, 6 lime, 1 potash, and 1 magnesia. Cordilleras, in andesite or diorite porphyry; Vosges Mountains, near Dresden, and Iceland.

Saccharite, compact, or fine granular; white or apple-green; Frankenstein, Silesia, and Canada; seems a variety.

** 6. LABRADORITE.— $\begin{cases} \ddot{Al}\ \ddot{Si}^2 + (\dot{Ca}, \dot{Na})\ \ddot{Si}, \text{ or} \\ \dot{Al}\ \ddot{Si} + \dot{R}\ \ddot{Si}. \end{cases}$

Triclinohedric; 0P : $\breve{P}\infty$ = 86° 25′, 0P : ∞P′ = 114° 9′.

26′. Crystals rare; mostly massive and granular; macles like those of pericline (fig. 107). Cleavage basal, very perfect, brachydiagonal less so; both usually striated. H.=6; G. 2·68...2·74. Translucent, or only on the edges; vitreous, on the cleavage pearly or resinous. Gray, passing into white, green, yellow, or red. The faces of $\infty \breve{P} \infty$ often exhibit very beautiful changing colours,—blue, green, yellow, red, or brown,—sometimes in bands intersecting at certain angles. B.B. fuses more readily than orthoclase to a compact colourless glass; soluble when pulverized in n. acid. Chem. com. 53·7 silica, 29·7 alumina with 1 to 2 iron peroxide, 12·1 lime, and 4·5 soda with 0·3 to 2 potash, 0·1 to 2 magnesia, and 1 to 3 water—the latter probably not essential.

Common constituent of dolerite, greenstone, the gabbro, and hypersthene rocks. Labrador, Finland, Harz, Meissner, Tyrol, Mourne Mountains, Campsie and Milngavie near Glasgow, and Skye; also Etna and Vesuvius, and in meteoric stones.

Scolexerose, from Pargas, is a pure lime-labradorite. *Glaucolite*, from Lake Baikal, pale blue or greenish, with traces of cleavage in two directions, and G.=2·72...3·2, is not distinct. *Saussurite*, compact, dull, subtranslucent; gray, inclining to blue, green, or red; B.B. fuses to a gray or greenish-white enamel, and is not acted on by acids; is merely an impure labradorite. Alps near Geneva, Harz, Styria, Apennines, and Corsica.

7. COUZERANITE.—$2\,\ddot{\mathrm{A}}\mathrm{l}\,\ddot{\mathrm{S}}\mathrm{i}^2 + 3\,(\dot{\mathrm{C}}\mathrm{a},\ \dot{\mathrm{K}},\ \dot{\mathrm{N}}\mathrm{a},\ \dot{\mathrm{M}}\mathrm{g})\,\ddot{\mathrm{S}}\mathrm{i}$.

Monoclinohedric; $C = 87°$, $\infty P = 96°$. Cleavage clinodiagonal. H.=6; G.=2·69. Opaque, vitreous, or resinous. Pitch-black, blackish-blue, or gray. B.B. melts to a white enamel; not affected by acids. Chem. com. by Dufresnoy's analysis, 52·37 silica, 24·02 alumina, 11·85 lime, 1·40 magnesia, 5·52 potash, and 3·96 soda. Couzerans in the Pyrenees.

8. ANORTHITE, Christianite.— $\begin{cases} \dddot{Al}\,\ddot{Si} + \dot{Ca}\,\ddot{Si}, \textit{ or} \\ 3\,\dddot{Al}\,\ddot{Si} + \dot{R}^3\,\dddot{Si}. \end{cases}$

Triclinohedric; 0P : ∞P∞ = 85° 48′; ∞P′ : ∞′P = 120° 30′. Crystals and macles like albite, with angle between *P* and *P′* = 188° 24′. Cleavage, basal and brachydiagonal perfect. H. = 6; G. = 2·7...2·76. Transparent or translucent; vitreous. Colourless or white. B.B. fuses to a clear glass; soluble without gelatinizing in con. h. acid. Chem. com. 43·9 silica, 36·3 alumina, and 19·8 lime with 1 to 5 magnesia, 0·3 to 8 soda, 0·2 to 1 potash, and 0·1 to 2 iron peroxide. Monte Somma, Iceland, Java.

Amphodelite has the same composition and a close resemblance in crystalline forms, cleavage, and macles; is reddish-gray, or dirty peach-blossom red. Lojo in Finland, and Tunaberg in Sweden. *Indianite* from the Carnatic; gelatinizes with acids; and B.B. is infusible.

*9. OLIGOCLASE.—2 $\dddot{Al}\,\ddot{Si}^3 + \dot{Na}^2\,\ddot{Si}^3$, *or* $\dddot{Al}\,\ddot{Si}^2 + \dot{Na}\,\dddot{Si}$.

Triclinohedric; 0P : $\infty\breve{P}\infty$ = 86° 45′; ∞P′ : ∞′P about 120°. Crystals rather rare, and macles resemble albite. Cleavage, basal perfect; brachydiagonal less perfect; ∞P′ imperfect. H. = 6; G. = 2·64...2·68. More or less translucent; vitreous; pearly or resinous on the cleavage. White, with a tinge of green, gray, or red. B.B. melts easier than orthoclase or albite to a clear glass; not affected by acids. Chem. com. 63 silica, 23 alumina, and 14 soda; but 20 to 24 alumina, 7 to 12 soda, 1 to 4 potash, 5 to 4 lime, 0 to 1 magnesia, and 0 to 4 iron peroxide. Scotland, Scandinavia, Ural, Harz, and Morea. The *Sunstone* or *Aventurine felspar* from Tvedestrand, Norway, Lake Baikal, and Ceylon, with a fine play of colour, belongs to this species. *Hafnefiordite*, in lava, Hafnefiord, Iceland; G. = 2·729; is a lime-oligoclase.

10. LATROBITE, Diploite.— $4\,\dddot{Al}\,(\dddot{M}n)\,\ddot{Si} + 3\,(\dot{Ca}, \dot{Mg}, \dot{K})\,\ddot{Si}^2$ (?).

Triclinohedric; crystals indistinct, prismatic; mostly massive. Cleavage in three directions, intersecting at 91°,

93° 30′, and 98° 30′; fracture uneven. H. = 5 to 6; G. = 2·7. Translucent; vitreous. Rose-red to reddish-white. B.B. becomes white, intumesces, and melts on the edges to a porous mass. Amitok Island in Labrador, and Bolton in Massachusetts.

11. PETALITE.—$4\dddot{\dot{A}}l\,\ddot{S}i^4 + 3\,(Li, \dot{N}a)\,\ddot{S}i^4$.

Probably mono- or tri-clinohedric, but only coarse granular. Cleavage in one direction distinct, in a second less so, and mere traces of a third. H. = 6·5; G. = 2·4...2·5. Greenish, grayish, or reddish white, to pale red. Translucent; vitreous or pearly. B.B. melts easily into an obscure porous glass, colouring the flame red; not affected by acids. Chem. com. 77·1 silica, 18·4 alumina, 3·3 lithia, and 3·1 soda. Utoe, Bolton in Massachusetts, and York in Canada.

*12. SPODUMENE, Triphane. $\begin{cases} 4\dddot{\dot{A}}l\,\ddot{S}i^3 + 3\,(\dot{L}i, \dot{N}a, \dot{K})\,\ddot{S}i, \textit{ or} \\ 4\dddot{\dot{A}}l\,\ddot{S}i^2 + \dot{L}i^3\,\ddot{S}i^2. \end{cases}$

Monoclinohedric; C. = 69° 40 $\infty P = 87°$; isomorphous, with augite (diopside). Cleavage, prismatic ∞P perfect; orthodiagonal more perfect, chiefly massive or foliated. H. = 6·5...7; G. = 3·1...3·2. Translucent; vitreous or pearly. Pale greenish-gray or white to apple-green; streak white. B.B. intumesces slightly, tinging the flame momentarily purplish-red, and fuses easily to a colourless glass; not affected by acids. Chem. com. 65·0 silica, 28·7 alumina, and 6·3 lithia, with 0·1 to 2·5 soda, 0 to 4·5 potash, and 0 to 1 lime. Utoe in Sweden, Sterzing and Lisens in the Tyrol, Killiney near Dublin, Peterhead in Scotland, and crystals at Norwich in Massachusetts.

Killinite.—Crystalline foliated. Cleavage along a prism of 135°. H. = 4; G. = 2·65. Greenish-gray, yellow or brownish-green. B.B. melts difficultly to a white porous enamel. Chem. com. $2\,\dddot{\dot{A}}l\,\ddot{S}i^2 + \dot{R}\,\ddot{S}i^2 + 3\,\dot{H}$; $\dot{R}$, being potash, lime, magnesia, iron protoxide, and lithia. Killiney near Dublin, with spodumene.

13. KASTOR.—2 $\ddot{A}\dot{l}\,\ddot{S}i^{6} + \dot{L}i\,\ddot{S}i^{2}$.

Monoclinohedric. Cleavage distinct in two directions, meeting at $141\frac{1}{2}°$. H. = 6...6·5; G. = 2·38...2·40. Transparent; splendent vitreous. Colourless. B.B. melts difficultly to a transparent colourless bead, tinging the flame deep carmine-red; not soluble in n. acid. Chem. com. 78·7 silica, 18·6 alumina, and 2·7 lithia. Elba. Probably a variety of petalite.

14. POLLUX.—$\ddot{A}\dot{l}\,\ddot{S}i^{3} + \dot{K}\,\ddot{S}i + \dot{N}a\,\ddot{S}i + \dot{H}$ (?).

Massive. Traces of cleavage; fracture conchoidal. H. = 6...6·5; G. = 2·87...2·89. Transparent; splendent vitreous. Colourless; optically binaxial. B.B. melts on thin edges to an enamel-like porous glass, colouring the flame reddish-yellow. Elba, with castor. Both much resemble quartz.

15. ZYGADITE.—$\ddot{S}i, \ddot{A}\dot{l}, \dot{L}i$.

Triclinohedric, in macles like albite. H. = 5·5; G. = 2·51. Subtranslucent; vitreous. Reddish or yellowish white. Andreasberg.

16. AMORPHOUS FELSPAR.

Mineral substances, with no regular structure, and rather rocks than minerals.

*(*a*.) OBSIDIAN.—Compact in globular grains or masses. Fracture conchoidal; brittle. H. = 6...7; G. = 2·2...2·4. Semitransparent to translucent on the edges; vitreous. Black, gray, green, red, and brown, or striped and spotted. B.B. melts to a foamy mass, a glass or enamel. Chem. com. indeterminate, but 70 to 80 silica, 6 to 12 alumina, 3 to 10 soda, 3 to 6 potash, 1 to 7 lime, 1 to 2 magnesia, and 1 to 6 iron peroxide. Streams or detached masses near volcanoes, as Iceland, Lipari Islands, Milo, Santorin, Teneriffa, Mexico, and Hungary.

*(*b*.) PUMICE.—Porous, vesicular, or fibrous. Fracture conchoidal or flat; very brittle. White, gray, yellow, brown, or black. H. = 5; G. in powder = 2·19...2·2; in masses swims on water. B.B. melts more or less easily to a white

enamel. Chem. com. like obsidian, of which it seems a peculiar state. Andernach on the Rhine, Lipari, and Ponza Islands. Used as a polishing material.

(*c.*) PEARLSTONE.—Roundish concentric globules imbedded in a vesicular basis. Fracture conchoidal; very brittle. H.=6; G.=2·2...2·4. Pearly. Reddish, bluish, or ash-gray; also yellow, red, or brown in stripes or spots. B.B. melts to a white fungus-like mass. Chem. com. indefinite, or a mixture of felspar and opal, with 2 to 4 per cent. water. Hungary, Siberia, Mexico. *Sphærulite*, small spherical concretions in pearlstone in Hungary and Mexico, and in pitchstone in Arran and Meissen.

*(*d.*) PITCHSTONE.—Compact, slaty, or in concentric scaly concretions. Fracture conchoidal; splintery. H.=5·5..6; G.=2·2...2·3. Subtranslucent to opaque; resinous. Gray, green, yellow, red, brown, black. B.B. melts to a porous glass or gray enamel. Chem. com. indefinite; but 64 to 76 silica, 11 to 14 alumina, 1 to 3 lime, 1 to 6 soda, 0 to 6 potash, 0 to 7 magnesia, 1 to 4 iron peroxide, and 5 to 9 water. Beds or veins at Tokai, Kremnitz, Schemnitz in Hungary, Meissen, Saxony, Newry in Ireland, and Arran in Scotland (the latter said to contain 2 per cent. of bitumen).

FAMILY III.—SCAPOLITE.

Crystallization tetragonal or hexagonal (prehnite rhombic). Cleavage more or less perfect. H.=5...6, or a little more in prehnite; G. 2·6...3. All fusible and soluble in acids, and gelatinize. Chem. com. anhydrous silicates of alkalies or lime, and of alumina. They are generally transparent or translucent. Colourless, but often with green or yellow tinge and resinous lustre. They occur chiefly in volcanic or in plutonic rocks.

*17. SCAPOLITE, Wernerite. $\begin{cases} \ddot{Al}^2\,\ddot{Si} + (3\,\dot{Ca}, \dot{Na})\,\ddot{Si}, \text{ or} \\ 2\,\ddot{Al}\,\ddot{Si} + \dot{R}^3\,\ddot{Si}^2. \end{cases}$

Tetragonal; P 63° 32. Crystals ∞P, $\infty P\infty$, P, often

long prismatic; also massive and granular or columnar. Cleavage, $\infty P\infty$ rather perfect, ∞P less perfect. H. = 5 ...5·5; G. = 2·6...2·8. Transparent or translucent; vitreous, pearly, or resinous. Colourless, but pale gray, green, yellow, or red. B.B. melts with effervescence to a vesicular glass; in the closed tube many show traces of fluorine; with solution of cobalt become blue; soluble in h. acid. Chem. com. 49·9 silica, 27·6 alumina (with 0 to 3·8 iron peroxide), 22·5 lime and soda (but 12 to 21 lime, 1 to 7 soda, 0 to 2 magnesia, and 1 to 3 potash). Analyses differ widely, and some resemble the anorthite, others the labradorite felspars. Arendal, Tunaberg, Pargas, Bolton in Massachusetts, and Governeur in New York. Easily known by its indistinct rectangular cleavage, the resinous lustre on fracture surfaces, and its action before blowpipe.

18. MEIONITE.—$\ddot{Al}^2\ddot{Si}^3 + 3\dot{Ca}^2\ddot{Si}$.

Tetragonal; P 63° 48′. Crystals, $\infty P\infty$. P . ∞P, prismatic. Cleavage, $\infty P\infty$ perfect, ∞P imperfect. Fracture conchoidal, H. = 5·5...6; G. = 2·6...2·7. Translucent and transparent; vitreous. Colourless or white. B.B. fuses with much intumescence to a vesicular glass; soluble in h. acid without gelatinizing. Chem. com. 42·5 silica, 31·5 alumina, and 26 lime (but 21 to 24 lime, 0·5 to 2 soda, 0·3 to 1 potash, and 0 to 1 magnesia.) Somma, Vesuvius.

19. The following are varieties of, or closely related to scapolite;—

Nuttalite.—Tetragonal; P 64° 40′; forms and cleavage like scapolite. H. = 5·5; G. = 2·74...2·75. Vitreous; on fracture resinous. Ash or greenish gray. B.B. like scapolite. Bolton in Massachusetts.

Barsowite.—Granular or compact, with one distinct cleavage. Translucent on the edges; pearly. Snow-white. Gelatinizes in warm h. acid. Chem. com. about 49 silica, 34 alumina, 5·6 lime, and 1·5 magnesia. Barsowskoi in Ural.

Bytownite, translucent; vitreous; light greenish-blue, Bytown in Upper Canada; is similar.

20. PALAGONITE. $\left\{\begin{array}{l}(\dddot{Al}, \dddot{Fe})^2\ \ddot{Si}^3 + 3\ (\dot{Ca}, \dot{Mg}, \dot{Na})\ \ddot{Si}^3 \\ +9\ \dot{H}.\end{array}\right.$

Amorphous; fracture conchoidal. H. nearly 5; G.=2·4. Transparent or translucent; resinous to vitreous. Wine-yellow to yellowish-brown. B.B. fuses readily to a shining magnetic bead. Easily soluble in acid. Palagonia in Sicily, Iceland, Galapagos, Nassau, and Cassel. Rather a rock.

21. DIPYR.—$3\ \ddot{Al}\ \ddot{Si} + 4\ (\dot{Ca}, \dot{Na})\ \ddot{Si}^2$.

Tetragonal, in rounded eight-sided prisms. Cleavage, ∞P and $\infty P\infty$. Scratches glass. G = 2·646. Vitreous. Whitish or reddish. B.B. becomes opaque, and melts readily to a white vesicular glass. Slightly affected by acids. Chem. com. 55·7 silica, 25·1 alumina, 9·1 lime, and 10·1 soda. Mauléon, and Castillon in the Pyrenees.

*22. NEPHELINE, Elæolite. $\left\{\begin{array}{l}\ddot{Al}^4\ \ddot{Si}^5 + 4\ (\dot{Na}, \dot{K})\ \ddot{Si}, \text{ or} \\ 2\ \ddot{Al}\ \ddot{Si} + \dot{R}^2\ \ddot{Si}.\end{array}\right.$

Hexagonal; P 88° 6′. Crystals, $\infty P \cdot 0P$ and $\infty P \cdot 0P \cdot P$, imbedded, or in druses; also massive granular. Cleavage, basal and ∞P imperfect. Fracture conchoidal or uneven. H. = 5·5...6; G. = 2·58...2·64. Transparent or translucent; vitreous. Colourless or white (nepheline); or more opaque, dull resinous, and green, red, or brown (elæolite). B.B. melts difficultly (nepheline), or easily with slight effervescence (elæolite), into a vesicular glass. Soluble and gelatinizes in h. acid. Chem. com. 44·84 silica, 33·04 alumina, 16·05 soda, 6·07 potash, with 0·2 to 2 lime, and 0·5 to 1·5 iron peroxide. Nepheline at Monte Somma, Capo di Bove, Katzenbuckel in the Odenwald, Aussig, and the Lausitz. Elæolite in the zircon syenite at Laurvig, Fredriksvärn, Brevig, and Miask.

Davine.—$\frac{1}{2}$ P 51° 46′; long prismatic. G.=2·43. Contains a little chlorine and carbonic acid. Vesuvius and Somma.

23. CANCRINITE.—$\ddot{Al}^4\ \ddot{Si}^5 + 4\ \dot{Na}\ \ddot{Si} + 2\ \dot{Ca}\ \ddot{C}$.

Hexagonal; massive and columnar. Cleavage, prismatic ∞P perfect. H.=5...5·5; G.=2·42...2·46. Translucent

or transparent; resinous, vitreous, or pearly on cleavage. Green, yellow, and rose-red. B.B. melts to a white vesicular glass. Soluble with effervescence in h. acid. Chem. com. one atom of a nepheline silicate with two atoms carbonate of lime = 39·3 silica, 29 alumina, 17·6 soda, and 14·1 carbonate of lime. Miask, and Litchfield in Maine; but in the latter the carbonate is $\dot{N}a\,\ddot{C} + \dot{C}a\,\ddot{C}$. *Stroganowite* has the soda chiefly replaced by lime. Slüdänka River in Dauria.

24. GEHLENITE.—$(\ddot{Al}, \ddot{Fe})\,\ddot{Si} + (\dot{Ca}, \dot{Mg}, \dot{Fe})\,\ddot{Si}$.

Tetragonal. Crystals 0P. ∞P, thick tabular or short prismatic. Cleavage, basal rather perfect, ∞P traces. H. = 5·5 ...6; G. = 2·9...3·1. Translucent on the edges; dull resinous. Mountain, leek, or olive green, to liver-brown. B.B. melts difficultly in thin fragments. Gelatinizes with h. acid. Chem. com. 31·4 silica, 20 to 24 alumina, 3 to 6 iron peroxide, 35 to 38 lime, 0 to 4 magnesia, 0 to 1·7 iron protoxide, and 1 to 3 water. Mount Monzoni in the Fassa Valley.

25. HUMBOLDTILITE.—$(\ddot{Al}, \ddot{Fe})\,\ddot{Si} + 2\,(\dot{Ca}, \dot{Mg}, \dot{Na}, \dot{K})\,\ddot{Si}^2$.

Tetragonal; P 66° 24′; 0P . ∞P, tabular or short prismatic. Cleavage, basal perfect. H. = 5...5·5; G. = 2·91...2·95. Translucent on the edges; vitreous or resinous. Yellowish-white, honey-yellow, and yellowish-brown. B.B. melts easily to a light, or blackish coloured glass. Gelatinizes with h. acid. Chem. com. about 40 silica, 32 lime, 6 to 7 magnesia, 2 to 4 soda, 0·3 to 1·5 potash, 6 to 11 alumina, and 4 to 10 iron peroxide. Vesuvius and Capo di Bove. Melilite, Somervillite, and Zurlite are identical. *Sarkolite*, from Vesuvius, is similar.

*26. PREHNITE, Koupholite. $\begin{cases} \ddot{Al}\,\ddot{Si} + 2\,\dot{Ca}\,\ddot{Si} + \dot{H}, \text{ or} \\ \ddot{Al}\,\ddot{Si} + \dot{Ca}^2\,\ddot{Si} + \dot{H}. \end{cases}$

Rhombic; ∞P 99° 56′, $3\breve{P}\infty$ 33° 0′, $\frac{3}{2}\breve{P}\infty$ 126° 40′. Crystals 0P . P, or ∞P (*M*) . 0P (*P*) . $\infty\breve{P}\infty$ (*l*) . $3\breve{P}\infty$ (*o*) (fig. 108), tabular or short prismatic, in druses, fan-shaped or cock's-comb groups. Also granular or spherical, reni-

form and fibrous. Cleavage, basal rather perfect, ∞P imperfect. H. = 6...7; G. = 2·8...3. Semitransparent or translucent on the edges; vitreous, on 0P pearly. Colourless, but mostly greenish-white, olive, apple, or leek-green. When heated becomes polar-electric. B.B. melts easily, with much intumescence, to a porous enamel. Soluble in con. h. acid, but only gelatinizes perfectly when previously ignited or fused. Chem. com. 44·4 silica, 24·6 alumina, 26·7 lime, and 4·3 water (but with 0·1 to 7 peroxide of iron and manganese). Cape of Good Hope; Bourg d'Oisans in Dauphiné; Ratschinges and Fassa in Tyrol; Friskie Hall and Campsie, Dumbartonshire; Hartfield Moss, Renfrewshire; Corstorphine Hill, the Castle Rock, and Salisbury Crags, near Edinburgh; Mull; Skye; and Dalnabo, near Glengairn, Aberdeenshire.

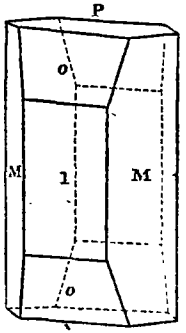


Fig. 108.

Prehnitoid, like prehnite, but with no water and scarce affected by h. acid. Wexio in Sweden.

27. KARPHOLITE.—$\dot{\ddot{A}}l\ \ddot{S}i + \dot{M}n\ \ddot{S}i + 2\ \dot{H}$.

Rhombic; radiating or stellated and acicular. H = 5...5·5; G. = 2·9...3. Translucent; silky. Straw to wax yellow. B.B. intumesces and forms an opaque brown glass, scarcely affected by acids. Chem. com. 37 silica, 30·6 alumina, 21·6 manganese protoxide, 10·8 water, with iron protoxide and fluoric acid. Schlakenwald and Wippra in the Harz.

28. The following minerals may follow prehnite:—

(*a.*) *Kirwanite.*—Spheroidal; radiating fibrous. H. = 2; G. = 2·9. Opaque; dark olive-green. B.B. becomes black, and partially fuses. Chem. com. *40·5 silica, 11·4 alumina,* 23·9 iron protoxide, 19·8 lime, and 4·4 water. Mourne Mountains, Ireland.

(*b.*) *Huronite.*—Granular or foliated. H. = 3·25; G. = 2·86. Translucent; pearly or resinous. Pale yellowish-

green. B.B. infusible, but grayish-white. Not affected by acids. Chem. com. 45·8 silica, 33·9 alumina, 4·3 iron protoxide, 8·1 lime, 1·7 magnesia, and 4·2 water. Lake Huron.

(*c.*) *Neurolite.*—Fine columnar. H.=4·25; G.=2·47. Translucent or opaque. Greenish-yellow. B.B. infusible, but becomes snow-white and pulverulent. Chem. com. 73 silica, 17·4 alumina, 3·3 lime, 1·5 magnesia, and 4·3 water. Stamstead in Lower Canada.

Family IV.—Haloid Stones.

These minerals are so named from their resemblance to salts. Their crystallization is rhombic or monoclinohedric. H.=4...6; G.=2·3...3·1. Soluble in acids. Generally infusible, or with difficulty. Most colour the B.B. flame bluish-green from phosphoric acid, being compounds of this acid with alumina, in some also with magnesia or iron protoxide. Are brightly-coloured minerals, of blue, green, or yellow tints. Most contain water, and do not form constituents of rocks.

29. Lazulite, Azurite.—$\dddot{Al}^2\,\ddot{\dot{P}} + (\dot{Mg},\ \dot{Fe})^3\,\ddot{\dot{P}} + 2\,\dot{H}$. Monoclinohedric; C.=88° 2′, ∞P 91° 30′, P 99° 40′, −P 100° 20′, P∞ 30° 2′; crystals pyramidal, tabular, or prismatic, but rare; usually massive or granular. Cleavage, prismatic ∞P imperfect; fracture uneven, splintery. H. =5...6; G.=3...3·1. Translucent on the edges; vitreous. Indigo, smalt, or other shades of blue inclining to green or white; streak white. In closed tube yields water and loses its colour. B.B. intumesces, but does not melt. With cobalt solution assumes a fine blue colour. Scarcely affected by acids till after ignition, when almost wholly soluble. Chem. com. 44·1 phosphoric acid, 31·7 alumina, 9 to 12 magnesia, 2 to 10 iron protoxide, 1 to 4 lime, and 5·7 water. Werfen in Salzburg, Vorau (*Voraulite*) and Krieglach in Styria, Tijuco in Brazil, and Lincoln county in North Carolina.

30. CALAITE, Turquois.—$\dddot{\dot{A}}l^2\,\ddot{\dot{P}} + 5\,\dot{H}$.

Reniform; stalactitic or incrusting. Fracture conchoidal. H.=6; G.=2·6...2·8. Opaque or translucent on the edges; dull or waxy. Sky-blue, greenish-blue, rarely green; streak greenish-white. In the closed tube yields water, decrepitates violently, and becomes black. B.B. infusible, but colours the flame green. Soluble in acids. Chem. com. 46·89 alumina, 32·57 phosphoric acid, and 20·54 water, but mixed with phosphate of iron and copper. Silesia, Lausitz, and Voigtland. Oriental turquoise, in veins at Meschid near Herat; in pebbles in Khorazan, Bucharia, and Syrian desert. Takes a fine polish, and is valued as an ornamental stone.

31. FISCHERITE.—$\dddot{\dot{A}}l\,\ddot{\dot{P}} + 8\,\dot{H}$.

Rhombic; ∞P 118° 32′, mostly in crusts or indistinct six-sided prisms. H.=5; G.=2·46. Transparent; vitreous; green. Slightly soluble in h. or n., wholly in s. acid, and on heating becomes white or partly black. Chem. com. 42 alumina, 29 phosphoric acid, 29 water, with a little lime and copper oxide. Nischnei Tagilsk.

Peganite.—Probably rhombic, ∞P 127° nearly; in very small prismatic crystals or thin crusts. Emerald, grass-green, or white. H.=3...4; G.=2·49...2·54. Chem. com. like Fischerite, but 6 $\dot{H}$. Strigis in Saxony.

Variscite.—Reniform; incrusting; weak resinous; greasy feel; green. G.=2·34...2·38; H.=5. In the closed tube it yields much water, and assumes a rose-red colour. Chem. com. chiefly phosphate of alumina, with water, magnesia, protoxide of iron, and chrome-oxide. Plauen in the Voigtland.

*32. WAVELLITE, Lasionite.—$\dddot{\dot{A}}l^3\,\ddot{\dot{P}}^2 + 12\,\dot{H}$.

Rhombic, ∞P 126° 25′, $\breve{P}\infty$ 106° 46′; crystals $\infty\breve{P}\infty$ (P). ∞P (d). $\breve{P}\infty$ (o) (fig. 109); but generally small, acicular, and in hemispherical radiated fibrous masses. Cleavage,

along ∞P and $\bar{P}\infty$ rather perfect. H.=3·5...4; G.=2·3...2·5. Translucent; vitreous. Colourless, but generally yellowish or grayish, sometimes green or blue. In closed tube yields water. B.B. in the forceps colours the flame weak bluish-green; on charcoal intumesces, and becomes snow-white. Soluble in acids. Chem. com. 38·0 alumina, 35·3 phosphoric acid, and 26·7 water; but generally traces of fluoric acid (2 per cent.). Beraun in Bohemia, Amberg in Bavaria, Frankenberg in Saxony, Tanne in the Harz, Barnstaple in Devonshire, St Austle in Cornwall, near Clonmel, Cork and Portrush in Ireland, and in the Shiant Isles in Scotland; also in New Hampshire and Tennessee.



Fig. 109.

33. WAGNERITE.—$\dot{M}g^3\,\ddot{\ddot{P}} + Mg\,F$.

Monoclinohedric; $C=63°\ 25'$, $\infty P\ 57°\ 35'$, $P\infty\ 71°\ 53'$. Cleavage, prismatic and orthodiagonal imperfect. Fracture conchoidal or splintery. H.=5...5·5; G=3·0...3·1. Translucent or transparent; resinous. Wine-yellow, honey-yellow, and white. B.B. fuses with great difficulty in thin splinters to a dark greenish-gray glass. Chem. com. 43·32 phosphoric acid, 11·35 fluorine, 37·64 magnesia, and 7·69 magnesium; but with 3 to 4·5 iron protoxide, and 1 to 4 lime. Very rare; Werfen in Salzburg.

34. AMBLYGONITE. $\begin{cases} \ddot{\ddot{A}}l^5\ \ddot{\ddot{P}}^3 + (\dot{L}i, \dot{N}a)^5\,\ddot{\ddot{P}} + \\ (Al\,F^3 + (Li, Na)\,F). \end{cases}$

Rhombic; coarse granular. Cleavage, $\infty P\ 106°\ 10'$ tolerably perfect. Fracture uneven and splintery. H.=6; G.=3...3·1. Translucent; vitreous; pearly on ∞P. Grayish or greenish-white to pale mountain-green. In closed tube yields water, sometimes corroding the glass. B.B. fuses very readily to a transparent glass, opaque when cold. Finely pulverized it is slowly soluble in acids. Chem. com. 47·9 phosphoric acid, 34·5 alumina, 6·9 lithia, 6 soda, and 8·3 fluorine. Penig in Saxony.

Family V.—Leucite.

Tesseral. H.=5...6; G.=2·2...2·5. All fusible except leucite, and all soluble and mostly gelatinize in hydrochloric acid. They are mostly silicates of alumina and of alkalies (or lime), often with chlorine, sulphur, or sulphuric acid. Their colours are white, gray, or often blue. They are mostly found imbedded in volcanic rocks.

*35. Leucite.—($\dddot{Al}\ \ddot{Si}^3 + \dot{K}\ \ddot{Si}$, *or* $3\ \dddot{Al}\ \ddot{Si}^2 + \dot{K}^3\ \ddot{Si}^2$.)

Tesseral; only 202 (fig. 6). The crystals generally single. Cleavage, hexahedral very imperfect. Fracture conchoidal. H.=5·5...6; G.=2·4...2·5. Transparent to translucent on the edges; vitreous, inclining to resinous. Colourless, but grayish, yellowish, or reddish-white, or gray; streak white. B.B. infusible; with cobalt solution becomes blue. Soluble in h. acid, without gelatinizing. Chem. com. 55·7 silica, 23·1 alumina, and 21·2 potash. Abundant in the lavas of Vesuvius, the tufas near Rome, and the peperino of Albano; also at the Kaiserstuhl, and near Lake Laach. Readily distinguished from Analcime by its infusibility and by never showing faces of the cube.

36. Porcelain Spar.—$3\ \dddot{Al}\ \ddot{Si}^2 + (\dot{Ca}, \dot{Na})^4\ \ddot{Si}^3 + \frac{1}{2}\dot{K}\ Cl$.

Rhombic; ∞P 92° nearly. Massive and coarse granular. Fracture uneven. H.=5·5; G.=2·67...2·68. Translucent, or only on the edges; vitreous or pearly. Yellowish or bluish-white, or pale gray. B.B. fuses easily with intumescence to a colourless vesicular glass. Soluble without gelatinizing in con. h. acid. Chem. com. 49·55 silica, 27·40 alumina, 15·62 lime, 4·75 soda, 1·39 potassium, and 1·29 chlorine. Obernzell near Passau (*Passauite*), forming porcelain earth when decomposed.

37. Sodalite.—$3\ (\dddot{Al}\ \ddot{Si} + \dot{Na}\ \ddot{Si}) + Na\ Cl$.

Tesseral; ∞O (fig. 3); massive and granular. Cleavage, ∞O more or less perfect. Fracture conchoidal or uneven. H.=5·5; G.=2·28...2·29. Translucent; vitreous, inclin-

ing to resinous. White, gray, green, and rarely blue. B.B. becomes white and fuses easily alone, sometimes intumescing to a clear glass; with difficulty in borax. Gelatinizes with acids. Chem. com. 37·8 silica, 31·3 alumina, 25·3 soda, and 5·6 chlorine. Greenland, Vesuvius, Valle di Noto in Sicily, Lake Laach, Ilmen Hills, Fredriksvärn in Norway, and Litchfield in Maine.

*38. HAUYNE.—$3\,(\ddot{\dddot{A}}l\,\ddot{S}i + \dot{N}a\,\ddot{S}i) + 2\,\dot{C}a\,\ddot{\dddot{S}}$.

Tesseral chiefly ∞O, but more common in grains. Cleavage, ∞O more or less perfect. H.=5...5·5; G.=2·4...2·5. Semitransparent or translucent; vitreous or resinous. Azure or sky blue; streak bluish-white. B.B. decrepitates violently, and melts to a bluish-green vesicular glass. Soluble, and gelatinizes in h. acid. Chem. com. 32·5 silica, 27·1 alumina, 16·4 soda, 9·9 lime, and 14·1 sulphuric acid. Vesuvius, Mount Vultur near Melfi, the Campagna of Rome, and Niedermendig near Andernach.

39. NOSEAN.—$3\,(\dddot{\dddot{A}}l\,\ddot{S}i + \dot{N}a\,\ddot{S}i) + \dot{N}a\,\dddot{\dddot{S}}$.

Tesseral, like hauyne, but oftener granular. H.=5·5; G.=2·25...2·27. Translucent; vitreous to resinous. Ash or yellowish gray, sometimes blue, brown, or black. B.B. becomes paler, and melts to a vesicular glass. Soluble in acids. Chem. com. 36·65 silica, 30·59 alumina, 24·82 soda, and 7·94 sulphuric acid; but with 1 to 1·5 lime and 0·6 chlorine. Lake Laach and Rieden, near Andernach, on the Rhine. *Skolopsite*, granular, smoke-gray and reddish-white; G.=2·53; is very similar. Kaiserstuhl in the Breisgau.

40. ITTNERITE.—$\dddot{\dddot{A}}l\,\ddot{S}i + (\dot{N}a, \dot{C}a)\,\ddot{S}i + 2\,\dot{H}$.

Tesseral, but only coarse granular. Cleavage, dodecahedral distinct; fracture, imperfect conchoidal. H.=5·5; G.=2·37 ...2·40. Translucent; resinous. Smoke, ash, or dark bluish-gray. In the closed tube yields much water. B.B. fuses, with much effervescence and sulphureous smell, to a vesicular opaque glass. Soluble, and gelatinizes in con. h. acid. Chem. com., by Whitney's analysis, 35·69 silica, 29·14 alu-

mina, 5·64 lime, 12·57 soda, 1·20 potash, 4·62 sulphuric acid, 1·25 chlorine, 9·83 water and loss. Kaiserstuhl near Freiburg.

*41. LAPIS-LAZULI, Lasurstein.

Tesseral; ∞O, but rarely distinct; generally massive and fine granular. Imperfect dodecahedral cleavage. H. =5·5; G.=2·38...2·42. Translucent on the edges; dull resinous or vitreous. Ultramarine or azure blue; streak light-blue. B.B. fuses readily to a white porous glass. In h. acid the powder is dissolved and gelatinizes, evolving sulphuretted hydrogen. Chem. com., by Varrentrapp's analysis, 45·50 silica, 5·89 sulphuric acid, 31·76 alumina, 9·09 soda, 3·52 lime, 0·86 iron, 0·42 chlorine, 0·95 sulphur, 0·12 water. Near Lake Baikal, China, Thibet, and Tartary. It is used for ornamental purposes, and the preparation of ultramarine-blue. The colour both in it and the hauyne seems caused by some compound of sulphur, probably with iron. A mode of preparing the artificial colour was discovered by Chr. Gmelin.

42. EUDIALITE.—[Żr S̈i + 2 (Ṅa, Ċa, Ḟe) S̈i], Na Cl.

Rhombohedric; R 73° 30′; also massive and granular. Cleavage, basal distinct. H.=5...5·5; G.=2·84...2·95. Semitranslucent or opaque; vitreous. Peach-blossom to brownish-red; streak white. B.B. fuses easily to a light-green opaque glass. Gelatinizes in hydrochloric acid. Chem. com., by Rammelsberg's analysis, 49·92 silica, 16·88 zirconia, 11·11 lime, 12·28 soda, 6·97 iron protoxide, 1·15 manganese protoxide, 1·19 chlorine, with 0·65 potash, and 0·3 water. Greenland.

**FAMILY VI.—ZEOLITES.

Crystallization chiefly rhombic and monoclinohedric; also tetragonal and tesseral. H.=3·5...6, or mostly scratched by steel; G.=2...3. Mostly hyaline, and white or red, gray or yellow coloured. Cleavage generally distinct. All yield water in closed tube; all fusible B.B.; all soluble in acids,

and mostly gelatinize or deposit silica. They are hydrated silicates of alkalies, or alkaline earths, mostly with silicates of alumina, but rarely contain magnesia. They are generally found in amygdaloidal cavities or fissures of trap or plutonic rocks, apparently as deposits from water percolating through them. Also in veins, but rare.

*43. ANALCIME. $\begin{cases} \dddot{Al}\,\ddot{Si}^3 + \dot{Na}\,\ddot{Si} + 2\,\dot{H}, \textit{ or} \\ 3\,\dddot{Al}\,\ddot{Si}^2 + \dot{Na}^3\,\ddot{Si}^2 + 6\,\dot{H}. \end{cases}$

Tesseral; crystals 202, seldomer $\infty O \infty$. 202 (fig. 110), in druses; *also granular*. Cleavage hexahedral, very imperfect; fracture uneven. H. = 5·5; G. = 2·1...2·25. Transparent to translucent on the edges; vitreous. White, grayish, greenish, yellowish, or reddish white; also flesh-red, and very rarely leek-green. B.B. melts quietly to a clear glass. Completely soluble and gelatinizes in h. acid. Chem. com. 55·2 silica, 22·9 alumina, 13·9 soda, and 8 water, with occasionally a little potash or lime. Seisser Alp in Tyrol, Dumbarton in Scotland, and in Siebenburg; Cyclopean Islands, Sicily; the Vicentine, Norway, Faroe, Iceland, Nova Scotia; also Giant's Causeway; and the Hebrides, Glenfarg, Salisbury Crags, and other parts of Scotland. *Sarcolite*, *Cuboit*, and the *Cluthalite*, from near Dumbarton, are varieties.

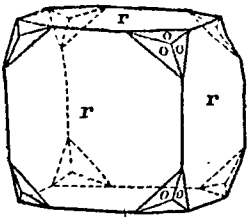


Fig. 110.

*44. NATROLITE, Mesotype. $\begin{cases} \dddot{Al}\,\ddot{Si}^2 + \dot{Na}\,\ddot{Si} + 2\,\dot{H}, \textit{ or} \\ \dddot{Al}\,\ddot{Si} + \dot{Na}\,\ddot{Si} + 2\,\dot{H}. \end{cases}$

Rhombic; ∞P 91°, P polar edges 143° 20′, and 142° 40′, middle edges 53° 20′; crystals, ∞P . P (fig. 111), fine prismatic, acicular or fibrous, and radiating. Cleavage, ∞P perfect. H. = 5...5·5; G. = 2·17...2·26. Pellucid; vitreous. Colourless or grayish-white, but sometimes bluish or yellow, seldom red or brown. Is *not* pyroelectric. B.B.

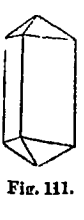


Fig. 111.

becomes obscure and melts quietly to a clear glass. Gelatinizes in h. acid. Chem. com. 48 silica, 26·6 alumina, 16·1 soda, and 9·3 water, with a little lime and iron oxides. Clermont in Auvergne, Alpstein in Hessia, Hohentwiel in Swabia, Norway; in Scotland, as in Mull, Canna, and near Tantallan Castle; and in Ireland, Nova Scotia, and other countries. *Bergmannite* and *Radiolite* are varieties.

Galactite.—H. = 4·5, with 4 lime and 10·5 water. Glenfarg, Kilpatrick, and Bishopstown. Probably distinct.

*45. SCOLEZITE, Needlestone. $\begin{cases} \ddot{\dot{A}}l\ \ddot{S}i^2 + \dot{C}a\ \ddot{S}i + 3\ \dot{H}, \textit{ or} \\ \ddot{\dot{A}}l\ \ddot{S}i + \dot{C}a\ \ddot{S}i + 3\ \dot{H}. \end{cases}$

Monoclinohedric; C = 89° 6′, ∞P 91° 35′, P 144° 20′; crystals, ∞P . P . −P, prismatic or acicular. Twin crystals very common, united by a face of ∞P∞, and one face with feathery striæ (fig. 112); also massive and radiating. Cleavage, ∞P rather perfect. H. = 5...5·5; G. = 2·2...2·3. Pellucid; vitreous, fibrous varieties silky. Snow-white, grayish, yellowish, and reddish white. Distinctly pyro-electric. B.B. bends and twists in a vermicular manner, and melts easily to a porous glass. In h. acid dissolves and gelatinizes. Chem. com. 46·6 silica, 25·8 alumina, 14 lime, and 13·6 water. Very fine on Staffa; at Berufiord in Iceland; in Faroe, Greenland; and the Vendyah Mountains in India; also in Tyrol, Ireland, &c.

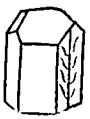


Fig. 112.

The following are either varieties of, or closely allied to, scolezite or natrolite :—

Mesolite, with 4 to 5 soda; Staffa, Antrim, and Iceland. *Caporcianite*, reddish-gray, radiating fibrous; Caporciano, Tuscany. *Lehuntite*, fine scaly, flesh-red; G. = 1·953; H. = 3·75; Glenarm, Ireland. *Poonahlite*, rhombic prisms of 92° 20′, otherwise like scolezite, from Poonah in Hindostan. *Brevicite*, radiated, massive, white, reddish-gray, or dark-red; Brevig. *Harringtonite*, compact, earthy, snow-white; Portrush in Ireland. *Antrimolite*, white, fibrous, and opaque; G. = 2·096; H. = 3·75; Antrim. *Stellite*, fine rhombic

prisms grouped in concentric stars; white, translucent, silky; H.=3...3·5; G.=2·612; Kilsyth, Scotland. *Mesole* or *Faröelite*, radiating, fibrous; transparent, pearly; white, yellow, or gray. H.3·5. Chem. com. 41·3 silica, 28·4 alumina, 11·5 lime, 5·7 soda, and 13·2 water. Faroe, Schonen; Storr, Uig, and Portree, in Skye. The last is perhaps a distinct species.

*46. THOMSONITE, Comptonite. $\left\{\begin{array}{l} 3\,\ddot{\dot{A}}\mathrm{l}\,\ddot{\dot{S}}\mathrm{i}+3\,\dot{C}\mathrm{a}\,\ddot{\dot{S}}\mathrm{i}+7\,\dot{H}, \textit{ or} \\ 3\,\ddot{\dot{A}}\mathrm{l}\,\ddot{\dot{S}}\mathrm{i}+\dot{R}^3\,\ddot{\dot{S}}\mathrm{i}+7\,\dot{H}. \end{array}\right.$

Rhombic; ∞P 90° 40′, usually like fig. 113, terminating in an extremely obtuse dome of 177° 35′, like the basis with the plane broken. In druses, fan-shaped or radiated. Cleavage, macrodiagonal and brachydiagonal equally perfect.

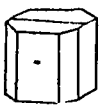


Fig. 113.

H.=5...5·5; G.=2·3...2·4. Translucent, but often obscure; vitreous, sometimes pearly. White. B.B. intumesces, becomes opaque, and fuses with difficulty to a white enamel. Soluble, and gelatinizes in h. acid. Chem. com. 38·2 silica, 31·6 alumina, 17·2 lime, with 1 to 8 soda, and 13 water. Vesuvius, Sicily, Bohemia, Tyrol, Iceland, Faroe, Scotland (Lochwinnoch, Kilpatrick Hills), and Nova Scotia. *Chalilite*, a compact variety; Antrim.

*47. STILBITE, Desmine. $\left\{\begin{array}{l} \ddot{\dot{A}}\mathrm{l}\,\ddot{\dot{S}}\mathrm{i}^3+\dot{C}\mathrm{a}\,\ddot{\dot{S}}\mathrm{i}^3+6\,\dot{H}, \textit{ or} \\ \ddot{\dot{A}}\mathrm{l}\,\ddot{\dot{S}}\mathrm{i}^3+\dot{C}\mathrm{a}\,\ddot{\dot{S}}\mathrm{i}+6\,\dot{H}. \end{array}\right.$

Rhombic; P polar edges, 119° 16′, and 114°; crystals, ∞$\breve{\mathrm{P}}$∞ (*M*) . ∞$\breve{\mathrm{P}}$∞ (*T*) . P (*r*) . 0P (*P*), (fig. 114), broad pyramidal, very often fascicular or diverging; also radiating or broad columnar, or macled. Cleavage, macrodiagonal very perfect. H. =3·5...4; G.=2·1...2·2. Translucent, or only on the edges; vitreous; pearly on ∞P∞. White, red, gray, yellow, and brown. B.B. intumesces greatly, and melts with difficulty to a white enamel. Decomposed by c.h. acid, leaving slimy silica.

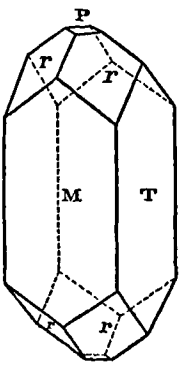


Fig. 114.

Chem. com. 58·2 silica, 16 alumina, 8·8 lime, with 1 to 3 soda or potash, and 17 water. Andreasberg in the Harz, Kongsberg and Arendal, Iceland, Faroe, and the Vendayah Mountains in Hindostan; in Scotland, in Skye, Kilpatrick, Kilmalcolm, and Arran. *Sphærostilbite* and *Hypostilbite* are related species. *Ædelforsite*; fibrous or columnar; H. = 6; G. = 2·6; is a stilbite with two atoms less water, or a laumonite mixed with quartz. Ædelfors in Sweden.

*48. HEULANDITE. $\begin{cases} \ddot{\dot{A}}l\,\dot{S}i^3 + \dot{C}a\,\ddot{\dot{S}}i^3 + 5\,\dot{H}, \textit{ or} \\ \ddot{\dot{A}}l\,\ddot{\dot{S}}i^3 + \dot{C}a\,\ddot{\dot{S}}i + 5\,\dot{H}. \end{cases}$

Monoclinohedric; C = 63° 40′, P∞ 50° 20′; crystals (∞P∞) . ∞P∞ . P∞ . 0P (fig. 115); mostly tabular, rarely prismatic in druses or radiated lamellar. Cleavage, clinodiagonal very perfect; brittle. H. = 3·5...4; G. = 2·1···2·2. Transparent to translucent on the edges; vitreous or pearly. White, but often flesh or brick-red, and yellowish or hair-brown. B.B. exfoliates, intumesces, and melts to a white enamel. Soluble in h. acid, leaving slimy silica. Chem. com. 59·9 silica, 16·7 alumina, 9 lime, and 14·5 water. Arendal, Kongsberg, Andreasberg, Fassa Valley, Iceland, Faroe, Nova Scotia, New Jersey, and the Vendayah Mountains, Hindostan; at Campsie, in Skye, and other parts of Scotland. *Beaumontite* is the same; Baltimore.

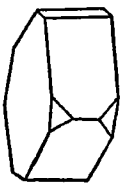


Fig. 115.

49. BREWSTERITE.—$\ddot{\dot{A}}l\,\ddot{\dot{S}}i^3 + (\frac{2}{3}\,\dot{S}r + \frac{1}{3}\,\dot{B}a)\,\ddot{\dot{S}}i^3 + 5\,\dot{H}$.

Monoclinohedric; C. = 86° 20′; crystals short prismatic, of several vertical prisms, bounded by an extremely obtuse clinodome (172°) (fig. 116), are mostly small. Cleavage, clinodiagonal very perfect. H. = 5...5·5; G. = 2·12 ..2·2. Pellucid; vitreous or pearly. White, gray, yellow, brown, or green. B.B. froths, intumesces, and fuses to a porous glass. Soluble in h. acid, and gelatinizes. Chem. com. 54·3 silica, 15·0 alumina, 10·1 strontia, 7·4 baryta with 1·3



Fig. 116.

lime, and 13·1 water; and thus with all the three alkaline earths. Strontian in Scotland, Giants' Causeway, Freiburg in the Breisgau, and the Pyrenees.

50. EPISTILBITE.—$\ddot{A}l\ \ddot{S}i^3 + \dot{C}a\ \ddot{S}i^3 + 5\ \dot{H}$.

Rhombic; ∞P 135° 10′, $\bar{P}\infty$ 109° 46′, $P\infty$ 147° 40′; in long prismatic crystals (fig. 117). Macles united by a face of ∞P are more common; also massive and granular. Cleavage, brachydiagonal very perfect. H.=3·5...4; G.=2·3...2·4. Pellucid; vitreous or pearly. Colourless or white. B.B. melts with intumescence to a porous enamel. Soluble without gelatinizing, but after ignition is insoluble. Chem. com. 59 silica, 17·5 alumina, 9 lime, with 1·5 soda, and 14·5 water, or like heulandite. Iceland and Faroe; also, it is said, in Skye, and at Portrush in Ireland.

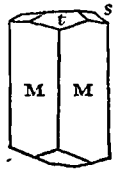


Fig. 117.

*51. APOPHYLLITE.—$4\ \dot{C}a^2\ \ddot{S}i^3 + \dot{K}\ \ddot{S}i^3 + 16\ \dot{H}$.

Tetragonal; P 121° 4′; crystals, $P.\infty P\infty$ (*m*) (fig. 118) and 0P, are pyramidal, or short prismatic, or tabular; usually in druses or lamellar. Cleavage, basal perfect; $\infty P\infty$ imperfect; brittle. H.=4·5...5; G.=2·3...2·4. Pellucid; vitreous; on 0P pearly (*ichthyophthalm*). Colourless, but yellowish, grayish, or reddish white, to rose or flesh red. B.B. exfoliates, intumesces, and melts easily to a white enamel. Powder readily soluble in h. acid, leaving slimy silica. Chem. com. 52·8 silica, 25·4 lime, 5·3 potash, and 16·5 water; in some with 0·24 to 1·54 fluorine. Occurs at Utoe in Sweden, Aussig in Bohemia, the Seisser Alp in Tyrol, St Andreasberg in the Harz, Nertschinsk in Siberia, in Greenland, Iceland, Faroe, and Raith in Fife.

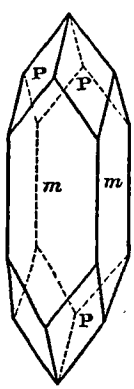


Fig. 118.

Gyrolite, spherical radiated concretions, with 50·7 silica, 1·48 alumina, 33·24 lime, 0·18 magnesia, and 14·18

water, seems a variety; Storr in Skye. Also *Xylochor*, from Iceland.

52. OKENITE, Dysclasite.—$\dot{C}a\ \ddot{S}i^3 + 2\ \dot{H}$.

Rhombic; $\infty P\ 122°\ 19'$; usually fine columnar or fibrous. H.=5; G.=2·28...2·36. Pellucid; slightly pearly. Yellowish to bluish-white. B.B. froths up and melts to an enamel. In powder easily soluble in h. acid, leaving gelatinous flakes; after ignition insoluble. Chem. com. 57 silica, 26 lime, and 17 water. On Disco Island, Greenland, Faroe, and Iceland.

53. PECTOLITE.—$8\ \dot{C}a\ \ddot{S}i + \dot{N}a^2\ \ddot{S}i^3 + 3\ \dot{H}$, *or* $6\ \dot{R}\ \ddot{S}i + \dot{H}$.

Monoclinohedric (?), but only spheroidal, radiating, and columnar. H.=5; G.=2·69...2·74. Translucent on the edges; slightly pearly. Grayish-white or yellowish. B.B. melts easily to a white enamel-like glass. Soluble in h. acid, leaving flaky silica; after ignition gelatinizes perfectly. Chem. com. 52·1 silica, 34·2 lime, 9·5 soda, with 0·6 to 1·6 potash and 4·2 water. Monte Baldo, Monte Monzoni in Tyrol, Kilsyth (*Wollastonite*), Ratho, Corstorphine near Edinburgh, and Storr in Skye.

54. LEVYNE.—$\ddot{A}l\ \ddot{S}i^2 + \dot{C}a\ (\dot{K}, \dot{N}a)\ \ddot{S}i + 4\ \dot{H}$.

Rhombohedric; R 79° 29'; crystals, 0R. R. $-\frac{1}{2}$R, thick tabular, in perfect intersecting macles (fig. 119). H.=4; G=2·1...2·2. Chem. com. 44·5 silica, 23·8 alumina, 10·7 lime, 1·6 potash, 1·4 soda, and 17·4 water. Otherwise like chabasite.



Fig. 119.

Faroe, Glenarm, Skye, and Hartfield Moss in Renfrewshire.

55. CHABASITE, Lime-Ch.—$\ddot{A}l\ \ddot{S}i^3 + \dot{C}a\ (\dot{N}a, \dot{K})\ \ddot{S}i + 6\ \dot{H}$.

Rhombohedric; R 94° 46'; R mostly alone, but also with $-\frac{1}{2}$R and -2R. Intersecting macles very common; crystals in druses and striated. Cleavage, R rather perfect. H.=4...4·5; G.=2...2·2. Transparent to translucent; vitreous. Colourless, grayish, yellowish, reddish to flesh-red. B.B. fuses to a finely porous enamel. Soluble in h. acid, leaving slimy silica. Chem. com. 48·2

silica, 20 alumina, 10·8 lime, with 0 to 2·5 soda, and 0·2 to 3 potash, and 21 water. Faroe, Iceland, Greenland, Aussig in Bohemia, Giants' Causeway, Kilmacolm in Renfrewshire, in Skye, and other places in Scotland. *Phacolite*, with rather less silica and more alumina, is a variety; Leipa in Bohemia.

56. GMELINITE, Soda-Chabasite. $\left.\begin{matrix}\\ \\ \end{matrix}\right\}$ $\ddot{\dot{A}}\dot{l}\ \ddot{S}i^3 + \dot{N}a\ (\dot{C}a, \dot{K})\ \ddot{S}i + 6\,\dot{H}$.

Hexagonal; P 80° 8′; crystals P . 0P . ∞P (fig. 120). The faces of P striated parallel to their polar edge; those of the prism horizontally. Cleavage, ∞P distinct. Gelatinizes with h. acid; otherwise like chabasite. Chem. com. 47·6 silica, 19·7 alumina, 12 soda, with 3 to 5 lime, and 0·4 to 2 potash, and 20·7 water. Glenarm in Antrim, Vicenza (*Sarcolite*). *Lederite*, with only 9 per cent. water, seems a variety; Cape Blomidon, Nova Scotia.



Fig. 120.

57. FAUJASITE.—$2\ \ddot{\dot{A}}\dot{l}\ \ddot{S}i^3 + (\dot{C}a,\ \dot{N}a)^2\ \ddot{S}i^3 + 18\ \dot{H}$.

Tetragonal; P 105° 30′. Fracture uneven; brittle. Scratches glass. G. = 1·923. Transparent; vitreous or adamantine. White or brown. B.B. intumesces and fuses to a white enamel. Soluble in h. acid. Chem. com. 46 silica, 17 alumina, 5 lime, 5 soda, and 27 water. Kaiserstuhl.

58. EDINGTONITE.—$4\ \ddot{\dot{A}}\dot{l}\ \ddot{S}i^2 + 3\ \dot{B}a\ \ddot{S}i + 12\ \dot{H}$.

Tetragonal, hemihedric; P 87° 9′; formed as a sphenoid (*P*), with polar edges 92° 51′; also $\frac{1}{2}$P (*n*), polar edges 129° 8′, and ∞P(*m*) (fig. 121). Cleavage, ∞P perfect. H. = 4...4·5; G. = 2·7...2·75. Translucent; vitreous. Grayish-white. B.B. fuses difficultly to a colourless glass. Chem. com. 37·3 silica, 23·7 alumina, 26·5 baryta, and 12·5 water (*analysis*). Kilpatrick Hills, Dumbartonshire.

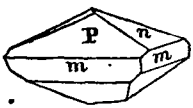


Fig. 121.

*59. HARMOTOME, Cross-stone.—$\ddot{\text{A}}\text{l}\ \ddot{\text{S}}\text{i}^3 + \dot{\text{B}}\text{a}\ \ddot{\text{S}}\text{i}^2 + 5\ \dot{\text{H}}$.

Rhombic; P polar edges 119° 4′, and 121° 6′, and ∞P 88° 14′; crystals, $\infty\breve{\text{P}}\infty$ (q) . $\infty\bar{\text{P}}\infty$ (o) . P . $\breve{\text{P}}\infty$, short prismatic. Generally in perfectly intersecting macles (fig. 122). Cleavage, brachydiagonal imperfect, macrodiagonal less distinct; brittle; fracture uneven. H.= 4·5; G.=2·3...2·5. Translucent; vitreous. Colourless, but white, gray, yellow, brown, or red. B.B. fuses rather difficultly but quietly to a clear glass. Soluble, but not readily, in h. acid, with deposition of silica. Chem. com. 47·25 silica, 15·67 alumina, 23·39 baryta (with 1 to 3 lime and 1 to 2·5 potash), and 13·76 water. Andreasberg, Kongsberg, Oberstein; Dumbartonshire and Strontian (*Morvenite*), Scotland.

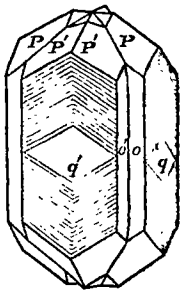


Fig. 122.

60. PHILLIPSITE.—$\ddot{\text{A}}\text{l}\ \ddot{\text{S}}\text{i}^3 + (\dot{\text{C}}\text{a},\ \dot{\text{K}})\ \ddot{\text{S}}\text{i} + 5\ \dot{\text{H}}$.

Rhombic; P polar edges 119° 18′ and 120° 42′. Forms, macles, and other characters like harmotome. G.=2·15... 2·20. B.B. fuses easily with slight intumescence; gelatinizes in h. acid. Chem. com. 48·6 silica, 20·2 alumina, 7·3 lime, 6·2 potash, and 17·7 water. Giessen, Marburg, Cassel, Iceland, and the Giants' Causeway.

61. HERSCHELITE.—$\ddot{\text{A}}\text{l}\ \ddot{\text{S}}\text{i}^3 + (\dot{\text{N}}\text{a},\ \dot{\text{K}},\ \dot{\text{C}}\text{a})\ \ddot{\text{S}}\text{i} + 3\ \dot{\text{H}}$.

Hexagonal; P polar edges, 124° 45′; crystals ∞P . 0P. H.=4·5; G.=2·06. Translucent; pearly; white. B.B. fuses readily to a white enamel. Chem. com. 48·5 silica, 20·1 alumina, 9·2 soda, 4·6 potash (with 0·2 to 5 lime), and 17·6 water. Aci Reale and Palagonia in Sicily.

62. ZEAGONITE.—$2\ \ddot{\text{A}}\text{l}\ \ddot{\text{S}}\text{i}^2 + 2\ (\dot{\text{C}}\text{a},\dot{\text{K}})\ \ddot{\text{S}}\text{i} + 7\ \dot{\text{H}}$.

Rhombic; P polar edges 120° 37′ and 121° 44′; crystals single or in groups. H.=5, on angles and edges=7 or more; G.=2·213. Transparent; vitreous. Colourless, white, or bluish. B.B. becomes white, falls down, shines,

and melts to a clear glass. Capo di Bove. Variety of Phillipsite (?).

63. GISMONDINE, Abrazite.—$\ddot{A}l\,\ddot{S}i^2 + \dot{C}a$ (K) $\ddot{S}i + 4\,\dot{H}$.

Tetragonal (or rhombic?); P 92° 30′; crystals, P or with $\infty P\infty$, in groups. Cleavage, P imperfect. H.=5, on edges and angles =6; G.=2·265. Semitransparent to translucent; vitreous. Grayish-white to pale-red. B.B. intumesces, shines, and melts to a white enamel. Chem. com. 35 silica, 29 alumina, 15·7 lime (with 2·8 potash), and 20·3 water. Vesuvius, Aci Castello, and Capo di Bove.

64. LAUMONITE.—$\ddot{A}l\,\ddot{S}i^3 + \dot{C}a\,\ddot{S}i + 4\,\dot{H}$.

Monoclinohedric; C=68° 40′, ∞P 86° 15′, $\infty P : 2P\infty$ 113° 30′; crystals prismatic, also columnar. Cleavage, prismatic perfect; clinodiagonal in traces; rather brittle. H.=3...3·5 (when fresh=5...6?); G.=2·2...2·3. Pellucid; vitreous; on cleavage pearly. White, grayish, yellowish, and reddish. In the air soon decomposed. B.B. intumesces and melts easily to a white enamel, which becomes clear in a stronger heat. Soluble and gelatinizes in h. acid. Chem. com. 51·8 silica, 21·5 alumina, 11·3 lime, and 15·4 water. Huelgoët in Brittany, Eule near Prague, Fahlun, Iceland, Faroe, Snizort and Storr in Skye, Dumbarton, and other parts of Scotland, and in North America.

65. LEONHARDITE.—$4\,\ddot{A}l\,\ddot{S}i^3 + 3\,\dot{C}a\,\ddot{S}i + 12\,\dot{H}$.

Monoclinohedric; ∞P 83° 30′, $\infty P : 0P$ 114°; crystals, $\infty P . 0P$, prismatic, and grouped in bundles; also granular or columnar. Cleavage, ∞P very perfect, basal imperfect. Very friable. H.=3...3·5; G.=2·25. Translucent on the edges; pearly; yellowish-white. B.B. exfoliates, froths, and melts easily to a white enamel. Becomes opaque, and decomposes quickly in the air. Chem. com. 53·9 silica, 23·8 alumina, 9·8 lime, and 12·5 water. Schemnitz.

66. GLOTTALITE—$\ddot{A}l\,\ddot{S}i + 3\,\dot{C}a\,\ddot{S}i + 8\,\dot{H}$.

Tesseral; O and $\infty O\infty$; in druses. H.=3...4; G.=2·18. Highly translucent; vitreous. Colourless or white.

B.B. melts with intumescence to a white enamel. Chem. com. 37·4 silica, 15·6 alumina, 25·3 lime, and 21·7 water. Near Port-Glasgow. Probably chabasite.

Family VII.—Mica.

Crystallization monoclinohedric or rhombic, and hexagonal or rhombohedric. Cleavage mostly very perfect in one direction (basal), and thin laminæ flexible. Pellucid, with a strong, often semimetallic lustre. H.=2...3, more rarely 1...6; G.=2·5...3. B.B. mostly fusible. Are silicates of alumina, with silicates of potash, magnesia, lithia, and protoxides of iron and manganese, with or without water. They are mostly constituents of the plutonic or volcanic rocks.[1]

**67. Potash-mica, Muscovite, Phengite, Binaxial-Mica. $\left\{\begin{array}{l} 3\,\ddot{\dot{A}}l\,\ddot{S}i + \dot{K}\,\ddot{S}i^3, \textit{ or} \\ 3\,\ddot{\dot{A}}l\,\ddot{S}i + \dot{K}\,\ddot{S}i. \end{array}\right.$

Monoclinohedric, or probably rhombic. Crystals chiefly rhombic or six-sided tables, with ∞P 120° and 60° nearly. Imbedded, or in druses; also scaly, foliated, or lamellar. Macles rather rare. Cleavage, basal highly perfect; sectile, and in thin laminæ elastic. H.=2...3; G.=2·8...3·1. Pellucid in various degrees; optically binaxial; metallic-pearly, on some faces vitreous. Colourless, but white, gray, green, red, brown, black, and rarely yellow. In closed tube usually yields water, with traces of fluorine. B.B. loses its transparency, and fuses to an obscure glass or white enamel. Not affected by h. or s.

[1] Neither the optical nor crystallographical characters of the micas, Nos. 67 to 71, are well determined. The magnesia micas were formerly regarded as monoaxial and hexagonal, but now appear to be binaxial, with the angle between the axes small; in biotite under 5°, often 0° to 1° or 2°; in phlogopite, 5° to 20°. The crystallization of the potash mica and lepidolite is more probably rhombic. The chem. com. also cannot be represented by any general formula.

acids. Chem. com. very variable, but nearly 48 silica, 39·8 alumina, and 12·2 potash; but analyses give 40 to 48 silica, 32 to 37 (rarely 9 to 10) alumina, 3 to 9 (or 36) peroxide of iron, 1 to 2 peroxide of manganese, 5 to 10 potash, 1 to 3 protoxide of iron (with traces of lime, magnesia, and soda), and most 1 to 4 water and 1 to 3 fluorine. The green micas (*Fuchsite*) also 4 to 6 chrome oxide. Abundant as a constituent of granite, gneiss, mica-slate, and other rocks. Large plates in Norway, Sweden, and especially in Siberia, often a yard in diameter, and used for windows, but become white on exposure. Fine crystals, Vesuvius, St Gotthardt, Pargas, Arendal, Utoe, Fahlun, Kimito, Cornwall, and Aberdeenshire.

68. DAMOURITE.—$3\,\ddot{A}l\,\dot{S}i + \dot{K}\,\dot{S}i^3 + 2\,\dot{H}$.

Fine foliated. H. = 1·5; G = 2·7...2·8. Translucent on the edges; pearly; yellowish-white. B.B. yields water, intumesces, becomes milk-white, and melts with difficulty to a white enamel. Soluble in sulphuric (not in h.) acid, leaving silica. Chem. com. 45·7 silica, 38·1 alumina, 11·7 potash, and 4·5 water. Pontivy in Brittany. The mica slate of St Gotthardt (*Paragonite*) is similar externally, but contains 50·20 silica, 35·90 alumina, 2·36 iron peroxide, 8·45 soda, and 2·45 water; and is infusible B.B. *Didrimite* from Zillerthal, and *Margarodite* from Connecticut, are similar hydrous micas.

*69. LITHIA-MICA, Lepidolite. } $3\,\ddot{A}l\,\ddot{S}i^2 + 2\,\dot{L}i\,\ddot{S}i + (KF, Si\,F^2)$.

Crystallization and physical characters like potash-mica, but colour often rose or peach-blossom red. In the closed tube shows evident fluorine reaction. B.B. melts *very easily* with effervescence to a colourless, brown, or rarely black magnetic glass, colouring the flame *red*. Imperfectly soluble in acids, wholly so after fusion. Chem. com. 51·6 silica, 28·5 alumina, 8·7 potash, 5·3 lithia, and 5·9 fluoric acid; analyses give 46 to 52 silica, 20 to 29 alumina, 0 to 18 iron peroxide, 0 to 5 manganese peroxide, 5 to 10

potash, 2 to 6 lithia, 4 to 6 fluorine, and 0 to 15 soda. Cornwall, Bohemia, Saxony; and also at Portsoy (serpentine), Loch Fine, and Ballahulish (limestone), in Scotland. It is sometimes used as an ornamental stone.

**70. BIOTITE, Magnesia-Mica. $\left\{\begin{array}{l}\ddot{\dot{A}}\dot{l}\,\ddot{S}i + (\dot{M}g, \dot{K}, \dot{F}e)^3\,\ddot{S}i^2, \textit{ or}\\ \ddot{\dot{A}}\dot{l}\,\ddot{S}i + \dot{R}^3\,\ddot{S}i.\end{array}\right.$

Rhombohedric; R 71° 4′ to about 73° (but perhaps rhombic); crystals mostly tabular, rarely short prisms. Cleavage, basal very perfect; sectile; in thin plates elastic. H.=2·5...3; G.=2·85...2·9. Transparent, but often only in very thin plates (and generally monoaxial?); metallic pearly. Usually dark-green, brown, or black; streak greenish-gray or white. B.B. difficultly fusible to a gray or black glass. Completely soluble in con. s. acid, leaving white pearly plates of silica. Chem. com. very variable, but analyses give 40 to 42 silica, 13 to 16 alumina, 0 to 20 iron peroxide, 0 to 20 iron protoxide, 10 to 25 magnesia, 4 to 10 potash, 0 to 2 fluorine, and 1 to 3 water. Pargas, Bodenmais, Monroe in New York, Greenland, near Aberdeen, and in other parts of Scotland. *Rubellan*, brownish-red, Bohemia and Saxony, seems a variety.

71. PHLOGOPITE.—$\ddot{\dot{A}}\dot{l}\,\ddot{S}i + (\dot{M}g, \dot{K}, \dot{N}a)^6\,\ddot{S}i^2$.

Rhombic (or rhombohedric?), in rhombic or hexagonal prisms. Cleavage, basal. Yellow or copper-red; also colourless, white, and brown. B.B. fuses to a white enamel. Chem. com. 38 to 42 silica, 13 to 20 alumina, 2 to 7 iron oxides, 25 to 30 magnesia, 6 to 10 potash, 1 to 5 soda, and 0·2 to 4 fluorine. In limestones, New York, Vosges Mountains, Sala.

72. LEPIDOMELANE.—$(\ddot{\dot{A}}\dot{l}, \ddot{\dot{F}}e)\,\ddot{S}i + (\dot{F}e, \dot{K})\,\ddot{S}i$.

Hexagonal, small six-sided tables. Cleavage, basal perfect; rather brittle. H.=3; G.=3·0. Highly vitreous; opaque and raven-black; or translucent and leek-green; streak mountain-green. B.B. becomes brown, and fuses to a black magnetic bead. Soluble in h. acid, leaving pearly scales of silica. Chem. com. 37·4 silica, 11·6 alumina, 27·7 iron per-

oxide, 12·4 iron protoxide, 9·2 potash, with 0·6 magnesia and lime. Persberg, Sweden.

73. CHLORITOID.—$\ddot{A}l^2\,\ddot{S}i + (\dot{F}e, \dot{M}g)^2\,\ddot{S}i$.

Granular, foliated. Cleavage, in one direction perfect; brittle. H. = 5·5...6; G = 3·55. Opaque; weak pearly. Blackish-green; streak greenish-white. B.B. infusible, but becomes darker and magnetic. Not affected by acids. Chem. com. 26·2 silica, 43·4 alumina, and 30·4 iron protoxide, with 0 to 4 magnesia, and mostly 6 to 7 water. Kosoibrod in the Ural, Tyrol. *Sismondine*, St Marcel in Piedmont, is similar; and *Masonite*, from Rhode Island.

74. OTTRELITE.—$\ddot{A}l^2\,\ddot{S}i^3 + 3\,(\dot{F}e, \dot{M}n)\,\ddot{S}i + 3\,\dot{H}$.

Thin hexagonal tables. Cleavage, parallel to the lateral faces, rather perfect. Scratches glass. G. = 4·4. Translucent; vitreous. Greenish or blackish-gray. B.B. melts difficultly on the edges to a black magnetic globule. Powder soluble in warm s. acid. Chem. com. 43·9 silica, 24·3 alumina, 17·0 iron protoxide, 8·5 manganese protoxide, and 6·3 water. In gray clay-slate at Ottrez in Belgium.

**75. CHLORITE (Ripidolite, *G. Rose.*) $\begin{cases} 2\,\dot{R}\,\ddot{S}i + \dot{R}^2\,\ddot{A}l + 3\,\dot{H}, \textit{ or} \\ 3\,\dot{R}^3\,\ddot{S}i + \ddot{R}^3\,\ddot{S}i + 9\,\dot{H}\ (\textit{Rams.}) \end{cases}$

Hexagonal; P 106° 50′; crystals tabular of 0P. ∞P, or 0P. P, (fig. 123), often in comb-like or other groups; generally foliated and scaly. Cleavage, basal perfect; laminæ flexible, but not elastic. H. = 1...1·5; G. = 2·78...2·96. Thin plates transparent or translucent; pearly. Leek to blackish green, often red transverse to the chief axis; streak greenish-gray. In the closed tube yields water. B.B. difficultly fusible on thin edges; soluble in con. sul. acid. Chem. com. when 4 $\dot{R}$

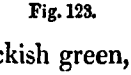


Fig. 123.

$= 3\,\dot{M}g + \dot{F}e$, = 26·3 sil., 21·8 al., 25·5 mag., 15·0 $\dot{F}e$, and 11·5 water.
$= 2\,\dot{M}g + 2\dot{F}$, = 24·6 ... 20·1 ... 15·9 ... 28·5 ... 10·9 ...

but the analyses variable. Common in the Alps, Scandinavia, the Ural, the Harz, Cornwall, and many parts of Scotland.

76. RIPIDOLITE, Pennine (Chlorite, *G. Rose*). $\left\{\begin{array}{l} 3\,\dot{M}g\,\ddot{S}i + \dot{M}g^2\,\ddot{A}l + 4\,\dot{H}, \textit{ or} \\ 3\,\dot{R}^3\,\ddot{S}i + \ddot{R}^2\,\ddot{S}i + 9\,\dot{H}\ (\textit{Rams.}) \end{array}\right.$

Rhombohedric (?); R 63° 15′; crystals chiefly tabular, in comb-like or fan-shaped groups. Cleavage, basal very perfect; sectile and flexible, but not elastic. H.=2...3; G.=2·6 ...2·77. Translucent, in thin leaves transparent; pearly. Green, but red by light transmitted transverse to the axis; streak greenish-white. B.B. exfoliates, becomes white, and fuses on the edges to a white enamel. Completely soluble in warm s. acid. Chem. com. 33·2 silica, 18·3 alumina, 35·7 magnesia, and 13·8 water, but with 1 to 7 peroxide, and 1 to 6 protoxide of iron. Zermatt in Valais, Schwarzenstein in Tyrol, and Mauléon in the Pyrenees. *Leuchtenbergite*, yellowish-white, from Slatoust, is the same.

N.B.—Chlorite and ripidolite may be regarded as one species, with the formula $\dot{R}^3\,(\ddot{S}i, \ddot{A}l)^2 + 3\,\dot{H}$ (*Rams.*)

77. CLINOCHLORE.

Monoclinohedric; C=76° 4′; 0P : P 113° 59′, 0P : ∞P 102° 8′. Macles common; also in groups and druses. Other characters and chem. com. like ripidolite, and the two probably identical. West Chester in Pennsylvania, Achmatowsk in Ural, and Leugast in Bavaria (massive).

Epichlorite, *Metachlorite*, *Helminth*, *Delessite*, and *Grengesite* are other chlorite-like minerals.

**78. TALC.—$\dot{M}g^4\,\ddot{S}i^5 + \dot{H}$, *or* $\dot{M}g^6\,\ddot{S}i^5 + 2\,\dot{H}$.

Monoclinohedric; ∞P2 = 105° 50′. Rarely found in six-sided or rhombic tables. Generally massive, granular, or scaly. Cleavage, basal very perfect. Soft, sectile, and flexible, in thin plates. H.=1; G.=2·68...2·80. Transparent in thin plates, and optically binaxial; pearly or resinous. Colourless, but generally greenish or yellowish-white, to apple, leek, or olive green. Feels very greasy. B.B. emits a bright light, exfoliates, and hardens (H.=6), but is infusible. Not soluble in h. or s. acid before or after ignition. Chem. com. 62·5 silica, 33·9 magnesia, and 3·6 water;

but analyses give 57 to 63 silica, 0 to 4·7 alumina, 30 to 35 magnesia, 0 to 2·3 iron protoxide, with traces of lime and nickel oxide, and 2 to 6 water. Greiner in Tyrol, Sala, Fahlun, the Pyrenees, Unst in Zetland, and many parts of the Scottish Highlands (talc-slate). Used as crayons; also for forming crucibles and porcelain.

Steatite.—Massive. Gray, red, yellow, or green. B.B. melts in fine splinters to a white enamel; but in other respects acts like talc, of which it seems only a compact variety. Briançon, Wunsiedel, the Lizard Point, Cornwall, and near Kirkcaldy, Scotland. Savage nations cut the steatite into culinary utensils. *Potstone* is a mixture of talc, chlorite, and other minerals. Steatite and talc are apparently altered forms of other minerals, chiefly augite and hornblende.

79. SCHILLER-SPAR.—$\dot{M}g(\dot{F}e, \dot{C}a)\, \ddot{S}i\, (\ddot{A}l, \ddot{C}r, \ddot{F}e) + \dot{H}$.

Mono- or tri-clinohedric; only granular and foliated. Cleavage very perfect in one direction, less so in another, meeting at 87°; fracture uneven, splintery. H. = 3·5...4; G. = 2·6...2·8. Translucent on thin edges; metallic pearly. Olive or pistacio green, yellow, brown, or black; streak greenish white. Imperfectly soluble in h., wholly in s. acid. B.B. becomes magnetic, and fuses in thin splinters on the edges. With borax traces of iron when hot, of chrome when cold. Chem. com. 43 silica, 26 magnesia, 2·7 lime, 7·4 iron protoxide, 3·3 iron peroxide, 2·4 chrome-oxide, 1·7 alumina, and 12·4 water. Baste in the Harz; other localities uncertain. Probably an altered augite.

Metaxite, massive, asbestiform, weak pearly, and greenish-white; H. = 2...2·5 nearly; G. = 2·52; Schwarzenberg; is closely related.

80. PYROSMALITE. $\left\{ \begin{array}{l} 15\, \ddot{F}e\, \ddot{S}i + 15\, \dot{M}n\, \ddot{S}i + 3\, \ddot{F}e\, \dot{H} \\ + Fe^{2}Cl^{3}. \end{array} \right.$

Hexagonal; P 101° 34′; crystals $\infty P . 0P$, tabular; also granular. Cleavage, basal perfect, ∞P imperfect; brittle. H. = 4...4·5; G. = 3·0...3·2. Translucent to opaque; resin-

ous, or metallic pearly. Liver-brown to olive-green. B.B. fuses to a black magnetic globule. Wholly soluble in c. n. acid. Chem. com. 38·5 silica, 22 iron protoxide, 22 manganese protoxide, 13 iron peroxide, 3·4 hydrochloric acid, and 1·1 water. Nordmark in Sweden.

81. CRONSTEDTITE, Chloromelan. $\left.\vphantom{\ddot{\ddot{}}}\right\}$ $\ddot{\ddot{\text{F}}}\text{e}^3\,\ddot{\ddot{\text{S}}}\text{i}+2\,(\dot{\text{F}}\text{e},\,\dot{\text{M}}\text{g})^2\,\ddot{\ddot{\text{S}}}\text{i}+5\,\dot{\text{H}}$.

Rhombohedric, chiefly radiated, columnar. Cleavage, basal perfect; thin laminæ elastic. H.=2·5; G.=3·3 ...3·5. Opaque or translucent; highly vitreous. Raven-black; streak dark-green. B.B. intumesces, and melts on the edges slowly to a steel-gray globule. Gelatinizes with h. or s. acid. Chem. com. 21·8 silica, 37·6 iron peroxide (with 2·9 manganese peroxide), 25·4 iron protoxide, 4·7 magnesia, and 10·5 water. Przibram in Bohemia; Huel Maudlin, Cornwall; and Conghonas do Campo in Brazil (*Sideroschisolite*).

82. STILPNOMELAN.—$(\dot{\text{F}}\text{e},\,\dot{\text{M}}\text{g})^2\,(\ddot{\ddot{\text{S}}}\text{i},\,\ddot{\ddot{\text{A}}}\text{l})^3+2\,\dot{\text{H}}$.

Massive or radiating-foliated. Cleavage in one direction very perfect; rather brittle. H.=3...4; G.=3...3·4. Opaque; vitreous, inclining to pearly. Greenish-black; streak greenish. B.B. fuses with difficulty to a black shining globule. Imperfectly decomposed by acids. Chem. com. 45·3 silica, 6·9 alumina, 38·3 iron protoxide (with 2 to 3 magnesia), and 9·5 water. Zuckmantel in Silesia, and Wielburg in Nassau.

83. CLINTONITE, Seybertite, Holmesite, Xanthophylite, Chrysophane. $\left\{\vphantom{\ddot{\ddot{}}}\right.$ $\ddot{\ddot{\text{S}}}\text{i},\,\ddot{\ddot{\text{A}}}\text{l},\,\dot{\text{M}}\text{g},\,\dot{\text{C}}\text{a},\,\dot{\text{F}}\text{e},\,\dot{\text{N}}\text{a},\,\dot{\text{H}}$.

Hexagonal tables, or massive and foliated. Cleavage very perfect in one direction, traces in another. H.=4·5 ...6; G.=3 to 3·16. Translucent; pearly on the cleavage planes. Wax-yellow, yellowish, or reddish-brown. Soluble in concentrated acids. B.B. infusible alone, but some become white and colour the flame yellow. Chem. com. uncertain. Amity, New York; Slatoust in the Ural.

Disterrite, Brandisite, from Monzoni, in Tyrol; H.=5 on

basis, 6...6·5 on the prism; when fresh blackish-green, but reddish-brown after exposure; is closely allied.

Groppite.—Coarse foliated. H.=2·5; G.=2·73. Rose or brown-red. Gropptorp in Sweden.

84. MARGARITE, Pearl-Mica, Emerylite. $\ddot{A}l^2\,\ddot{S}i + (\dot{C}a, \dot{N}a, \dot{M}g)\,\ddot{S}i + \dot{H}$.

Rhombic; rarely in six-sided tables; generally granular foliated. Cleavage, basal very perfect. Thin plates slightly elastic. H.=3·5...4·5; G.=3·032. Translucent; vitreous, or pearly. Snow-white, reddish-white, or pearl-gray. B.B. intumesces and difficultly fusible. Soluble in acids. Chem. com. 30·1 silica, 51·2 alumina, 11·6 lime, 2·6 soda, 0·5 to 3 magnesia, and 4·5 water. Sterzing in Tyrol; Asia Minor and Greece, with emery; and in Pennsylvania. *Diphanite,* in hexagonal prisms, bluish-white; B.B. fuses to an enamel; from the Ural; is nearly allied.

Euphyllite.—Like mica, but less readily cleavable. H.=4; G.=3. Pellucid; bright pearly; colourless. B.B. exfoliates with a bright light, and fuses on the edges. Contains 40 silica, 42 alumina, 1·4 iron peroxide, 1·4 lime, 3·3 potash, 5 soda, and 5·5 water. Unionville, Pennsylvania.

85. PYROPHYLLITE.—$\ddot{A}l\,\ddot{S}i^4 + \dot{H}$.

Rhombic (?), but radiated, columnar, or foliated. Cleavage very perfect; flexible; sectile. H.=1; G.=2·7...2·8. Translucent; pearly. Light verdigris-green to yellowish-white. B.B. swells up with many twistings to a white infusible mass. Partially soluble in sulphuric acid. Chem. com. 67 silica, 28·1 alumina, and 4·9 water, with 0·1 to 4 magnesia and lime. Ural, Spaa, Morbihan, and Westana in Sweden.

86. ANAUXITE.

Granular, with a very perfect cleavage in one direction. H.=2...3; G.=2·26. Translucent on the edges; pearly. Greenish-white. B.B. becomes white and fuses on thin edges. Chem. com. 55·7 silica, much alumina, a little magnesia, iron protoxide, and 11·5 water. Bilin in Bohemia.

87. PHOLERITE, Nacrite.—$\ddot{A}l^2\ \ddot{S}i^3 + 4\ \dot{H}$.

Fine scaly. H.=0·5...1; G.=2·35...2·57. Glimmering or pearly. Snow or yellowish white. B.B. infusible. Chem. com. 40 silica, 44·4 alumina, and 15·6 water. Fins in the Allier dept., Mons, Freiberg, and Naxos.

88. ROSELLAN, Polyargite, Rosite. $\ddot{A}l^2\ \ddot{S}i^3 + (\dot{K}, \dot{C}a, \dot{M}g)\ \ddot{S}i + 2\ \dot{H}$.

Small grains, with perfect cleavage. H.=2·5; G.=2·72. Translucent; splendent; fine rose-red. B.B. fuses with difficulty to a white slag. Chem. com. 45 silica, 35 alumina, 6·6 potash, 3·6 lime, 2·45 magnesia, and 6·5 water. Åker and Tunaberg in Sweden.

** FAMILY VIII.—SERPENTINE.

Massive or rhombic. H.=1...4, rarely more; G.=2·3 ...3. Often compact or fibrous. B.B. infusible or difficultly. Mostly soluble in acids. Colour often green. Chem. com. generally hydrated silicates of magnesia, partly replaced by protoxide of iron or lime, occasionally also with silicate of alumina or iron peroxide. Occur in plutonic or altered rocks; the serpentine often in large masses or beds.

**89. SERPENTINE. — $\dot{M}g^3\ \ddot{S}i^2 + 2\ \dot{H}$, *or* $\dot{M}g^9\ \ddot{S}i^4 + 6\ \dot{H}$.

Crystallization uncertain; generally massive, and granular or fibrous. Fracture flat-conchoidal, uneven, or splintery. Sectile and slightly brittle. H.=3...3·5; G.=2·5...2·6. Translucent to opaque; dull resinous. Green, gray, yellow, red, or brown, often in spots, stripes, or veins; streak white, shining. Feels greasy. In the closed tube yields water and becomes black. B.B. becomes white, and fuses with much difficulty on thin edges. Soluble in h. or easier in s. acid. Chem. com. 43·35 silica, 43·78 magnesia, and 12·87 water, but with 1 to 8 iron protoxide, and also carbonic acid, bitumen, and chrome oxide.

Varieties are,—1*st*, *Noble Serpentine;* 2*d*, *Marmolite* or

foliated; 3*d*, *Picrolite* or fibrous (H. = 3·5...4·5); 4*th*, *Common* or compact *Serpentine*; 5*th*, *Chrysotile* (*Baltimorite*, *Metaxite*), in fine asbestiform fibres, easily separated, with a metallic or silky lustre. G. = 2·219. Common in Norway, Sweden, North America, the Lizard Point in Cornwall, in Shetland, Portsoy, and many parts of Scotland. The chrysotile, at Reichenstein in Silesia, the Vosges Mountains, and North America.

90. ANTIGORITE.—$(\dot{M}g, \dot{F}e)^4 \ddot{S}i^3 + \dot{H}$ (?).

Very thin, straight, slaty laminæ. H. = 2·5; G. = 2·62. Transparent or translucent. Dull or blackish leek-green, in some parts with brown spots; streak white. B.B. very thin edges fuse to a yellowish-brown enamel. Chem. com. 46 silica, 2 alumina, 13 iron protoxide, 35 magnesia, and 3·7 water (but others 13 water). Antigorio in Piedmont.

91. HYDROPHITE.—$(\dot{M}g, \dot{F}e)^4 \ddot{S}i^3 + 4\,\dot{H}$.

Massive or fibrous. Fracture uneven. H. = 3...4; G. = 2·65. Mountain-green; streak lighter. B.B. infusible. Chem. com. 36·19 silica, 22·73 iron protoxide, 1·66 manganese protoxide, 21·08 magnesia, 2·89 alumina, 0·12 vanadic acid, 16·08 water. Taberg in Sweden, and New York.

92. PICROSMINE.—$2\,\dot{M}g\,\ddot{S}i + \dot{H}$.

Rhombic, but massive. Cleavage, $\infty\breve{P}\infty$ perfect; less so in other directions. Very sectile. H. = 2·5...3; G. = 2·5... 2·7. Translucent or opaque; vitreous, but pearly on $\infty\breve{P}\infty$. Greenish-white, gray, or blackish-green; streak colourless. Yields a bitter odour when breathed on (hence the name). In closed tube gives water and blackens. B.B. becomes white, and hard (= 5). Chem. com. 55·8 silica, 36·1 magnesia, and 8·1 water. Presnitz in Bohemia, and the Greiner in Tyrol.

Monradite.—Massive, foliated, translucent, and yellowish-gray. H. = 6; G. = 3·267. Has nearly the same composition, but with half the water. B.B. infusible. Bergen, Norway.

Picrophyll.—Dark-green, foliated. H. = 2·5; G. = 2·73.

B.B. infusible, but becoming white. Is also nearly related. Sala.

93. VILLARSITE.—$2\,\dot{M}g^2\,\ddot{S}i + \dot{H}$.

Rhombic; crystals $\infty P \cdot P \cdot 0P$, with $\infty P = 119°\ 59'$ (?); also granular. Fracture uneven. H.=3; G.=2·9...3. Translucent. Greenish or grayish-yellow. B.B. infusible; decomposed by acids. Chem. com. 41 silica, 53 magnesia, with 34 iron protoxide and 23 manganese protoxide, and 6 water. Probably a pseudomorph of olivine. Traversella in Piemont.

94. SPADAITE.—$\dot{M}g^5\,\ddot{S}i^6 + 4\,\dot{H}$.

Only massive, with splintery fracture. Sectile. H.=2·5. Translucent; weak resinous. Red; streak white. B.B. fuses to an enamel-like glass; soluble in con. h. acid, leaving slimy silica. Chem. com. 57 silica, 32 magnesia, and 11 water. Capo di Bove, near Rome.

95. GYMNITE, Deweylite.—$\dot{M}g^4\,\ddot{S}i^3 + 5\,\dot{H}$.

Only massive. H.=2...3; G.=2·2...2·4. Semi-translucent; resinous. Pale or dirty orange-yellow. B.B. becomes dark-brown, and fuses on very thin edges. Chem. com. 42·1 silica, 37 magnesia, and 20·9 water. Bare Hills near Baltimore, and Tyrol.

96. CHONIKRITE.—$3\,(\dot{M}g, \dot{C}a, \dot{F}e)\,(\ddot{S}i, \ddot{A}l) + 2\,\dot{H}$.

Massive. Fracture uneven. Sectile. H.=2·5...3; G.=2·91. Translucent; dull or glimmering. Snow, yellowish, or grayish-white. B.B. melts with ebullition to a grayish-white glass; soluble with deposition of silica in h. acid. Chem. com. 35·7 silica, 17·1 alumina, 22·5 magnesia, 12·6 lime, 1·5 iron protoxide, and 9 water. Elba.

97. PYROSCLERITE.—$3\,\dot{M}g^2\,\ddot{S}i + \ddot{A}l\,\ddot{S}i + 4\,\dot{H}$.

Massive. Cleavage, in two directions at right angles, the one perfect, the other imperfect; fracture uneven, splintery. Sectile. H.=3; G.=2·7...2·8. Translucent; dull, or weak pearly. Apple, emerald, or grayish green. B.B. fuses with difficulty to a gray glass. With borax forms a

chrome-green glass. The powder soluble in c. h. acid, leaving silica. Chem. com. 36·8 silica, 15·2 alumina (with 1·5 chrome-oxide), 33·7 magnesia, 3·5 iron protoxide, and 10·7 water. Elba, Aker in Södermanland.

98. KAMMERERITE.—$3\,\dot{M}g^2\,\ddot{S}i + \ddot{A}l\,\ddot{S}i + 5\,\dot{H}$.

Hexagonal; 0P . ∞P tabular and prismatic; but usually massive and foliated. Cleavage, basal perfect. Sectile; flexible. H.=1·5...2; G.=2·76. Translucent; pearly. Violet-blue, reddish, or greenish. Feels greasy. B.B. exfoliates without fusing. Chem. com. 37·0 silica, 14·2 alumina, 1·0 chrome-oxide, 31·5 magnesia, 1·5 lime, 1·5 iron protoxide, and 13·0 water. Bissersk in Siberia.

Rhodochrome.—Massive, fine scaly, splintery fracture. H. =2·5...3; G.=2·668. Greenish-black, in fine splinters peach-blossom red. Tino in Greece, the Ural, Styria, and near Baltimore.

Tabergite, from Taberg; *Vermiculite*, in fine scales, twisting up, B.B., from Millbury, Mass.; and *Loganite*, from Canada, are closely allied.

99. BRUCITE, Nemalite.—$\dot{M}g\,\dot{H}$.

Rhombohedric; R. 82° 15′; crystals 0R, ∞R; also foliated or columnar. Cleavage, basal very perfect. Sectile; fine laminæ flexible. H.=2; G.=2·3...2·4. Translucent; pearly. Colourless, or grayish and greenish-white. B.B. infusible; easily soluble in acids. Chem. com. 69 magnesia, and 31 water, but after exposure often contains carbonic acid and effervesces. *Nemalite* is the fine fibrous varieties with silky lustre. Swinaness in Unst, Hoboken in New Jersey, and Beresowsk in the Ural.

** FAMILY IX.—HORNBLENDE.

Monoclinohedric mostly. Distinct cleavage in several directions. H.=4...6, but generally 5, or scratch with knife; G.=2·5...4, but mostly high. Mostly coloured, ranging

from white, through green (rarely brown), to black. Lustre sometimes silky or metallic pearly. Soluble, but not very readily, in acids; and more or less easily fusible. Chem. com. anhydrous silicates and aluminates of lime, magnesia, iron protoxide, more sparingly of soda, yttria, and manganese protoxide. The chief species are essential constituents of the igneous rocks, and form by their decomposition highly fertile soils.

N.B.—Hornblende and augite rather represent groups of mineral substances than single species.

**100. HORNBLENDE, Amphibole. $\left\{ \begin{matrix} \dot{R}^5\,\ddot{S}i^6 = (\dot{M}g, \dot{C}a, \dot{F}e)^5\,(\ddot{S}i\,\ddot{A}l)^6, \textit{or} \\ \dot{R}^4\,Si^3. \end{matrix} \right.$

Monoclinohedric; C = 75° 10′, ∞P 124° 30′, P 148° 30′. The crystals short and thick, or long and thin prismatic, formed especially by ∞P (*M*) and (∞P∞) (*x*), and bounded on the ends chiefly by 0P and P (*r*) (fig. 124). Macles common, with the chief axis the twin axis. Very often radiated, fibrous or columnar, or granular. Cleavage, prismatic along ∞P 124½° very perfect, orthodiagonal and clinodiagonal very imperfect. H. = 5...6; G. = 2·9...3·4. Pellucid in all degrees; vitreous, but sometimes pearly or silky. Colourless; often white, but usually some shade of gray, yellow, green, brown, or black. B.B. fuses, generally intumescing and boiling, to a gray, green, or black glass. Those containing most iron are most fusible, and are also partially soluble in hydrochloric acid, which scarcely affects the others. Chem. com. very variable, and hardly reducible to any general formula. Analyses range from 40 to 60 per cent. silica, 0 to 17 alumina, 0 to 30 lime, 0 to 36 iron protoxide (or peroxide), 0 to 4 manganese protoxide, 0 to 8 soda, 0 to 3 potash, and 0 to 1·5 fluorine, with a little water.

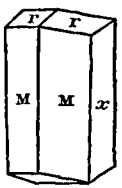


Fig. 124.

The more remarkable varieties are,—

1. *Tremolite, Grammatite,* or *Calamite.*—3 $\dot{M}g^5\,\ddot{S}i^6$ +

$\dot{Ca}^5\,\ddot{Si}^6 + \dot{Ca}\,\dot{F}$, with 60·85 silica, 24·53 magnesia, 13·74 lime, and 0·88 fluoric acid. White, gray, green, rarely yellowish or blue; in long prismatic crystals, often bent and striated longitudinally. Pearly or silky; semitransparent or translucent. B.B. fuses readily to a white or nearly colourless glass. Lapland, Sweden, Arendal, Campo Longo, St Gotthardt, and other parts of the Alps; in the Pyrenees, Silesia, Siberia, North America; Glen Tilt, Glenelg, Tiree, and many parts of Scotland.

2. *Actinolite, Actinote,* or *Strahlstein.*—Colour green, inclining to black, gray, or brown. Translucent, or only on the edges. Long prismatic crystals, or radiated columnar masses. B.B. melts to a greenish or blackish enamel. Sweden, Tyrol, North America, Glenelg, Isle Oronsay, and Aberdeenshire.

3. *Asbestus, Amianthus,* and *Byssolite.*—Fine fibrous. White, gray, or green. The fibres often easily separable, elastic, and flexible. Savoy, Tyrol, and Corsica. *Rock-cork,* felt-like, and swims on water; Saxony, Sweden, Portsoy and Leadhills in Scotland. *Rock-leather,* flat and flexible; Leadhills, Aberdeenshire, and Strontian; and *Rock-wood,* near Sterzing in the Tyrol.

4. *Anthophyllite.*—Clove-brown to leek-green; translucent, radiating, and columnar; pearly on cleavage planes. B.B. very difficultly fusible. In it the lime is chiefly replaced by protoxide of iron. Kongsberg and near Brevig in Norway, Greenland, and the United States.

5. *Hornblende.*—Green or black, seldomer brown or gray. G.=3·3...4. B.B. fuses rather easily to a yellow, greenish, or black enamel. $(\dot{Mg}^3 + \dot{Ca}^2)\,\ddot{Si}^6 + \dot{Fe}\,\ddot{Al}$, with 47·9 silica, 13·2 alumina, 15·5 magnesia, 14·4 lime, and 9·0 iron protoxide in the black variety. Three varieties are distinguished. (*a.*) The Noble or *Pargasite,* pale celadine or olive-green, and strong pearly or vitreous lustre; at Pargas in Finland, Tiree in Scotland. (*b.*) Common Hornblende, dark leek or

blackish green, opaque; a constituent of many rocks, as in Norway, the Alps, and Scottish Highlands (Ben Lair, East Rona). Streak greenish-gray. (*c.*) Basaltic, velvet-black, foliated, opaque; streak gray or brown, in basalt and volcanic rocks; Ural, Arendal, Bohemia.

Arfvedsonite.—$3\,\dot{F}e^{5}\,\ddot{S}i^{6} + \dot{N}a^{5}\,\ddot{S}i^{6}$, with 52·3 silica (2 alumina), 36·9 iron protoxide, 8·6 soda, and 2 lime. Pure black, opaque; streak grayish-green. Cleavage, very perfect along a prism of 123° 55′. G. = 3·44; H. = 6. Fusible in fine splinters in the flame of a candle. B.B. intumesces much, and melts to a black magnetic globule. Not soluble in acids. Greenland, Frederiksvärn in Norway, and Arendal.

The *Raphilite*, from Upper Canada, seems only tremolite.

Uralite.—Dark-green or greenish-black, with the outward form of augite, the internal structure and composition of hornblende. The Ural. Is probably a pseudomorph.

**101. AUGITE, Pyroxene. $\begin{cases}\dot{C}a\,\ddot{S}i + (\dot{M}g,\ \dot{F}e)\,\ddot{S}i \\ \dot{C}a^{3}\,\ddot{S}i^{2} + (\dot{M}g,\ \dot{F}e)^{3}\,\ddot{S}i^{2}.\end{cases}$ *or*

Monoclinohedric; C. = 74°, ∞P 87° 6′, P 120° 39′, —P 131° 29′, 2P 96° 36′. Crystals, ∞P (M). ∞P∞ (*r*). (∞P∞) (*l*) . P (*s*) . (fig. 125) ∞P . 2P . 0P . 3 P. ∞P∞, and ∞P∞,

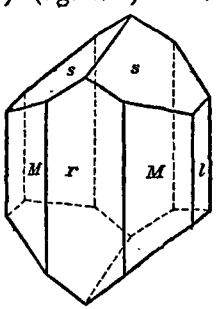


Fig. 125.

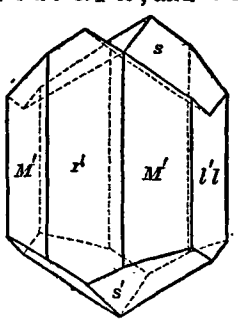


Fig. 126.

(∞P∞) . P∞ . ∞P, almost always prismatic, imbedded, or attached; also granular, columnar, and scaly. Macles

(fig. 126) common. Cleavage, prismatic along ∞P (with angles of 87° 6′ and 92° 54′), generally rather imperfect; orthodiagonal and clinodiagonal imperfect. H.=5...6; G.= 3·2...3·5. Pellucid in all degrees; vitreous; in some pearly on ∞P∞. Colourless, and white, but usually gray, green, or black. B.B. generally fusible; imperfectly soluble in acids. Chem. com. generally

	Silica.	Lime.	Magnesia.	Iron.
a. Magnesia-augite	56·36	25·46	18·18	...
b. Magnesia-iron-augite	52·72	23·81	8·50	14·97
c. Iron-augite	49·52	22·37	...	28·11

Analysis gives 47 to 56 silica, 20 to 25 lime, 5 to 15 magnesia, 1 to 20 iron protoxide, with 0 to 3 manganese protoxide, and 0 to 8 alumina. The alumina, chiefly found in very dark green or black augites, may replace part of the silica.

The more important varieties are—

1. *Diopside.*—Grayish or greenish-white, to pearl-gray or leek-green; streak white. Crystallized or broad-columnar, or concentric lamellar. Transparent to translucent on the edges. Not affected by acids. B.B. fuses to a whitish semitransparent glass. Mussa Alpe (*Mussite*) and Ala (*Alalite*) in Piedmont, Swarzenstein in the Tyrol; also the Alps, Scandinavia, Finnland, Ural, and North America.

2. *Sahlite, Malacolite.*—Green, rarely yellow, brown or red; streak white. Translucent, or only on the edges; vitreous, inclining to pearly. Seldom crystallized (*Baikalite*), mostly columnar or lamellar. B.B. melts to a dark-coloured glass. Fassathal (*Fassaite*), Piedmont, Arendal, Philipstadt in Sweden; in the vicinity of Lake Baikal (*Baikalite*); near Lake Lherz in the Pyrenees (*Lherzolite*); Sahla in Sweden; Glentilt, Glenelg, Tiree, in Scotland; Tyrol, and North America. *Coccolite* is a distinct granular sahlite or augite.

3. *Augite.*—Leek-green, greenish-black, or velvet-black,

rarely brown; streak greenish-gray. Vitreous to resinous; translucent or opaque. Only slightly affected by acids. B.B. fuses to a black, often magnetic glass. An essential component of many rocks, basalt, dolerite, clinkstone, and augite porphyry, in Germany, Auvergne, Vesuvius, and in many parts of Scotland; associated chiefly with labradorite, also with olivine, leucite, or nepheline; rarely if ever with quartz.

4. *Hedenbergite.*—Black or blackish-green; opaque or translucent on the edges. B.B. melts to a black magnetic glass; seems a lime-iron augite; Tunaberg. *Jeffersonite*, from Sparta, New Jersey; *Hudsonite*, from the Hudson River; and *Polylite*, are related.

5. *Amianthus.*—Some asbestiform minerals are probably augite, but the greater number are rather hornblende.

6. *Breislackite.*—Fine yellowish or brown woolly crystals. Vesuvius, and Capo di Bove near Rome.

Hornblende and augite agree so closely in crystalline forms and chemical composition, that it has sometimes been proposed to unite them in one species. They, however, differ too widely to justify their union. Thus, hornblende contains more silica, and a half to one per cent. of fluoric acid, which does not appear in augite. Hornblende, too, is more fusible, and ranges lower in specific gravity (hornblende from 2·931 to 3·445; augite, 3·195 to 3·525). Though both possess a cleavage parallel to their vertical prisms, yet these differ in angular dimensions. They also occur in distinct geognostic positions. Hornblende in rocks containing quartz or free silica, and mostly with minerals that are neutral compounds of silica, as orthoclase and albite; augite in rocks that do not contain free silica, and mostly with minerals that are not neutral silicates, as labradorite, olivine, and leucite. Hence there are two distinct series of massive or igneous rocks; the hornblende series, including granite, syenite, diorite, diorite-porphyry, and red porphyry; and the augite series or hypersthene

rock, gabbro, dolerite, nepheline rock, augite-porphyry, and leucite-porphyry.

102. NEPHRITE, Jade. $\begin{cases} 2\ \dot{M}g\ \ddot{S}i + \dot{C}a\ \ddot{S}i, \textit{ or} \\ 3\ \dot{M}g\ \ddot{S}i + \dot{C}a\ \ddot{S}i. \end{cases}$

Compact; fracture coarse splintery. Very tenacious. H. = 6...6·5; G. = 2·9...3. Translucent, dull, or resinous. Leek-green, to greenish-white or blackish-green. Feels slightly greasy. B.B. become white and melt with difficulty to a gray mass. Chem. com. 57·7 silica, 24·8 magnesia, 17·4 lime; or 58·5 silica, 28·3 magnesia, and 13·2 lime, but with 1 to 3 protoxide of iron and 1 to 2·5 water. China and the East, also in New Zealand. Seem varieties of hornblende or augite. Cut into ring-stones or amulets.

103. BOLTONITE.—$(\dot{M}g, \dot{F}e, \dot{C}a)^5\ \ddot{S}i^2$.

Granular; cleavage, one perfect, two others in traces. Translucent. Bluish-gray changing to yellowish-gray on exposure. B.B. infusible. Chem. com. 46 to 47 silica, 43 to 44 magnesia, 6 iron protoxide, and 3·5 lime. Bolton, Massachusetts.

*104. HYPERSTHENE, Paulite.—$(\dot{M}g, \dot{F}e)\ \ddot{S}i$.

Isomorphous with augite, ∞P 87°. Crystalline and granular, or disseminated. Cleavage, orthodiagonal very perfect, prismatic ∞P distinct, clinodiagonal very imperfect. H. = 6; G. = 3·3...3·4. Opaque or translucent on thin edges; vitreous or resinous, but metallic pearly on the cleavage planes, of which one is copper-coloured, two silvery. Pinchbeck-brown, inclining to copper-red, pitch-black, and grayish-black; streak greenish-gray. Not affected by acids. B.B. melts more or less easily to a greenish-black glass, often magnetic. Chem. com. generally 46 to 58 silica, 0 to 4 alumina, 11 to 26 magnesia, 1 to 5 lime, 13 to 34 iron protoxide, 0 to 6 manganese protoxide. Paul's Island (*Paulite*), Labrador, and Greenland. Hypersthene rock in Norway, Elfdal in Sweden, Skye and Ardnamurchan in Scotland. Also Cornwall; the Harz, and other parts of Germany.

*105. BRONZITE.—(7 $\dot{M}g + \dot{F}e$) $\ddot{S}i^8$.

Monoclinohedric, like augite; C. = 72°, ∞P 86°; indistinct crystals or granular. Cleavage, orthodiagonal very perfect, ∞P imperfect, clinodiagonal in traces. H. = 4·5 ...5; G. = 3·2...3·5. Translucent, or only on the edges; resinous or vitreous on the more perfect cleavage planes, which are often slightly curved and fibrous; metallic-pearly or silky. Clove-brown to pinchbeck-brown, sometimes greenish or yellowish; streak white. Not affected by acids. B.B. very difficultly fusible to a dark-brown or blackish-green glass. Chem. com. 58·6 silica, 33·0 magnesia, and 8·4 iron protoxide; but also 1 to 2 alumina, 0 to 2·2 lime, and 0 to 3 manganese protoxide. Kraubat in Styria, Kupferberg in Baireuth, Ullenthal in Tyrol, and near Marburg.

*106. DIALLAGE.—($\dot{C}a$, $\dot{M}g$, $\dot{F}e$) $\ddot{S}i$.

Like augite, and only a variety, with very perfect cleavage in the clinodiagonal, a metallic-pearly lustre, and gray or pinchbeck-brown colour. B.B. melts easily to a grayish or greenish enamel. Chem. com. 50 to 53 silica, 1 to 5 alumina, 15 to 23 magnesia, 11 to 20 lime, and 5 to 12 manganese protoxide. Constituent of the Gabbro. Baste in the Harz, Silesia, the Alps, Apennines, and Ural. *Vanadine-bronzite*, containing soda and vanadic acid, and *Diaclasite*, seem merely diallage.

107. RHODONITE, Manganese-spar.—$\dot{M}n$ $\ddot{S}i$.

Monoclinohedric, crystalline, or granular. Cleavage, ∞P 87° 5′ imperfect, ($\infty P \infty$) perfect, also $\infty P \infty$. Brittle. H. = 5...5·5; G. = 3·5...3·6. Translucent; vitreous or partly pearly. Dark rose-red, bluish-red, or reddish-brown. Not affected by acids. B.B. fusible. Chem. com. 45·33 silica, and 53·67 manganese protoxide, with 3 to 5 lime, and 0 to 6 iron protoxide. Langbanshytta, Katharinenburg, the Harz, and New Jersey. The *Bustamite*, pale-greenish or reddish-gray, with 14 lime, Mexico; *Fowlerite*, New Jer-

sey, with 7 to 11 iron protoxide, and *Paisbergite*, Sweden, are varieties. *Hydropite*, *Photicite*, *Allagite*, and *Hornmanganese*, mere mixtures.

108. WOLLASTONITE, Tabular-spar.—$\dot{Ca}\,\ddot{Si}$.

Monoclinohedric; C.=84° 40′, ∞P 140°, or C.=69° 48′, ∞P. 87°, 28′. Very rarely crystallized, mostly broad prismatic or laminar. Cleavage, along 0P and ∞P∞ perfect, but planes uneven or rough; meet at 95° 23′. H.=5; G.=2·7...2·9. Translucent; vitreous, or pearly on cleavage. White, inclining to gray, yellow, red, or brown; streak white. Phosphoresces with heat or friction; gelatinizes in hydrochloric acid. B.B. difficultly fusible to a semitransparent glass. Chem. com. 52·5 silica and 47·5 lime, but with 0 to 2 magnesia, and 0 to 2 iron protoxide. Bannat, Finnland, Sweden, North America, Ceylon, Capo di Bove, Monaltrie in Aberdeenshire, and the Castle Rock at Edinburgh.

110. ACMITE.—$2\,\dddot{\dot{F}}e\,\ddot{Si}^3 + \dot{Na}^2\,\ddot{Si}^3$.

Monoclinohedric. Crystals long acute-pointed prisms. Cleavage like augite, ∞P (86° 56′). H.=6...6·5; G.=3·4...3·6. Nearly opaque; vitreous. Brownish or greenish-black; streak greenish-gray. Imperfectly soluble in acids. B.B. fuses easily to a black magnetic glass. Chem. com. 55·6 silica, 32 iron peroxide, and 12·4 soda, but with 1 to 3 manganese peroxide, and also 3 to 4 titanic acid. Eger and Porsgrund in Norway.

111. BABINGTONITE.—$\dot{R}^4\,\ddot{Si}^5$, *or* $\dot{Ca}^2\,\ddot{Si}^3 + 2\,\dot{Fe}\,\ddot{Si}$.

Triclinohedric; $\infty\breve{P}\infty\,(M) : \infty\breve{P}\infty\,(t) = 112°\ 30'$; $\infty P'\,(h) : \infty'P\,(g) = 90°\ 40'$; $0P\,(P) : \infty\breve{P}\infty = 92°\ 34'$, $0P : \infty\breve{P}\infty = 88°\ 0'$; crystals very low eight-sided prisms (fig. 127), small, attached. Cleavage, basal and brachydiagonal perfect. H.=5...5·5; G.=3·4...3·5. Thin laminæ translucent, greenish, and brownish. Splendent vitreous; black. Slowly soluble in boiling h. acid. B.B. fuses easily with effervescence to a

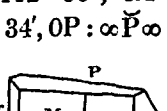


Fig. 127.

black magnetic bead. Chem. com. 54·7 silica, 20·3 lime, and 25·0 iron protoxide, but with 0·3 to 6 alumina, 2·2 magnesia, and 2 to 10 manganese protoxide. Arendal, Zetland, and Governeur in New York.

112. SORDAWALITE.—$\dddot{Al}\,\ddot{Si}^2 + 4\,(\dot{Mg}, \dot{Fe})\,\ddot{Si} + 2\,\dot{H}$.

Massive. Fracture conchoidal; brittle. H.=4···4·5. G.=2·55...2·62. Opaque; resinous or vitreous. Brownish-black or blackish-green; streak liver-brown. B.B. fuses to a black globule. Chem. com. 50·7 silica (with 2·68 phosphoric acid), 14 alumina, 19·6 iron protoxide, 10·9 magnesia, and 4·8 water. Sordawala in Finnland.

113. KROKYDOLITE.—$3\,\dot{Fe}\,\ddot{Si} + (\dot{Na}, \dot{Mg})\,\ddot{Si}^2 + 2\,\dot{H}$.

Very fine, easily separable, but tough elastic fibres. H.=4; G.=3·2...3·3. Translucent; silky, or dull. Indigo blue; streak lavender-blue. B.B. fuses easily to a black magnetic glass. Chem. com. 50·3 silica, 35·0 iron protoxide, 2·2 magnesia, 6·7 soda, and 5·8 water. Orange River in South Africa, Stavern in Norway, and Greenland.

114. PYRALLOLITE.

Triclinohedric; prismatic; usually columnar or granular. Cleavage, $\infty P'$ to $\infty' P = 94°\ 36'$ distinct. Fracture uneven, splintery; rather brittle. H.=3·5...4; G.=2·55... 2·60. Opaque, or translucent on the edges; resinous, or pearly. Greenish-white, asparagus-green, and yellowish-gray. B.B. becomes black, then white, and fuses with very much difficulty. Chem. com. silicate of magnesia with a little silicate of lime, water, and bituminous matter. Storgard, Finnland. Probably decomposed augite.

115. ISOPYRE.—$(\dddot{Al}, \dddot{Fe})^2\,\ddot{Si}^3 + 3\,\dot{Ca}\,\ddot{Si}$ (?).

Brittle; fracture conchoidal. H.=5·5...6; G.=2·90... 2·95. Opaque; vitreous. Grayish or velvet-black, sometimes with red spots; streak pale greenish-gray. Imperfectly soluble in acids. B.B. fuses to a magnetic globule. Chem. com., by Turner's analysis, 47·09 silica, 13·91 alumina, 15·43 lime, 20·07 iron peroxide, 1·94

copper oxide. St Just near Penzance, Calton Hill, Edinburgh (?).

116. TACHYLITE.—$\dddot{Al}\,\ddot{Si}^2 + 3\,(\dot{Fe}, \dot{Ca}, \dot{Mg}, \dot{Mn}, \dot{Na}, \dot{K})\,\ddot{Si}$.

Conchoidal. H. = 6·5; G. = 2·52. Opaque; vitreous or resinous. Velvet, brownish, or greenish black; streak dark-gray. B.B. fuses very easily to an opaque glass; soluble in h. acid. Vogelsberg (*Hyalomelan*) near Dransfeld, Munden, and Iceland. Seems a vitreous basalt.

FAMILY X.—CLAYS.

Amorphous, earthy, variously-coloured masses. H. = 1 ...5, but generally low or 1...3; G. = 1...3, but often about 2. Many have a shining streak, adhere to the tongue, feel greasy, and fall down in water. Some then form a ductile paste and are used for pottery. These are slightly affected by acids (under 25 per cent. of mass, soluble.) They are chiefly silicates of alumina, with about 10 to 12 per cent. water. Others with 20 to 25 per cent. water, and almost entirely soluble in acids, do not become plastic, and in the fire become misshapen or fuse; but often combine with grease or oil to an earthy soap. Many are thus of great economic importance. They rarely form true species, and are mostly indefinite mixtures or mere products of the decomposition of rocks and minerals.

*117. KAOLIN, Porcelain-earth.—$\dddot{Al}\,\ddot{Si}^3 + 2\,\dot{H}$.

Massive in beds and veins. Fracture uneven; fine-earthy, very soft, sectile, and friable. H. = 1; G. = 2·2. Opaque, dull. White or gray, inclining to blue, green, yellow, or red. Feels meagre when dry, and plastic when wet. B.B. infusible. Not affected by h. acid, but decomposed by warm s. acid, leaving silica. Chem. com. very variable, but approximates to 47·2 silica, 39·1 alumina, and 13·7 water. Chiefly a product of the decomposition of orthoclase, or of granite, porphyry, and other rocks containing this mineral. Cornwall and Devonshire in Britain,

Limoges in France, Meissen in Saxony, are the chief localities for the kaolin used in manufacturing porcelain.

*118. CLAY.

Clays are merely varieties of kaolin, mixed with quartz-sand, carbonate of lime, magnesia, the oxyhydrates of iron and manganese, or other substances. Generally they are compact and friable, of white, yellow, red, blue, gray, or brown colours. Their spec. gr. varies from 1·8 to 2·7. Varieties are,—*Pipe-clay*, grayish or yellowish-white, with a greasy feel; adheres strongly to the tongue; and when wet is very plastic and tenacious, and in the fire burns white. Abundant in Devonshire, and in the Trough of Poole in Dorsetshire; in France, Belgium, and Germany. Used for manufacturing tobacco-pipes and similar articles. *Potter's clay*, red, yellow, green, or blue, becoming yellow or red when burnt; more easily fused than the former, and often effervesces with acids. That used in the potteries in England comes chiefly from Devonshire. *Loam*, coarser and more impure, with more sand, and consequently less plastic. *Shale* or *Slate-clay*, grayish-black, and much mixed with bituminous or carbonaceous matter. *Bituminous shale*, known by its shining, resinous streak. *Black chalk*, with more carbon, leaves a black mark on paper. *Iron-clay* contains much peroxide of iron, is reddish-brown, and forms the basis of many amygdaloids and porphyries.

119. ROCK-SOAP, Bergseife.

Compact. Fracture earthy or conchoidal; sectile. H.=1...2. Streak resinous. Colour pitch-black and bluish-black. Feels very greasy; writes, but does not soil. Adheres strongly to the tongue, and falls to pieces in water. Chem. com. 44 to 46 silica, 17 to 26 alumina, 6 to 10 iron peroxide, 13 to 25 water. Arnstedt, Cassel, Bilin, and Isle of Skye. Used for crayons by painters, and for washing cloth.

120. PLINTHITE.

Compact; earthy. H.=2...3; G.=2·34. Brick-red or

brownish-red. Does not adhere to the tongue. B.B. becomes black, but is infusible. Chem. com. 30·9 silica, 20·8 alumina, 26·1 iron peroxide, 2·6 lime, and 10·6 water. Antrim in Ireland. *Erinite*, from the same place, is similar.

*121. GREEN-EARTH.—$\ddot{S}i$, $\ddot{A}l$, $\dot{F}e$, $\dot{M}g$ $\dot{K}$, $\dot{H}$.

Massive, forming crusts. Fracture, fine earthy; sectile. H.=1...2; G.=2·8. Opaque; streak shining. Green. Feels greasy. B.B. fuses to a black magnetic glass; not affected by acids. Common in the trap rocks of Faroe, Iceland, Scotland, and other countries; that used in the arts chiefly from Monte Baldo near Verona, and Cyprus. *Glauconite*, small round green grains, in the greensand of England, France, Germany, and North America, is essentially a hydrous silicate of iron protoxide and potash, but with 43 to 57 silica, 5 to 17 alumina, 19 to 27 iron protoxide, 5 to 15 potash, 1 to 4 magnesia, 0 to 3 lime, and 7 to 13 water. In New Jersey forms a valuable manure.

122. YELLOW-EARTH. — $(\ddot{\dot{F}}e, \ddot{A}l)^2$ $\ddot{S}i^3+4$ $\dot{H}$.

Fracture fine earthy or slaty. H.=1...2; G.=2·2. Ochre-yellow. Greasy; adheres slightly to the tongue, and pulverizes in water. B.B. infusible, but becomes red; partially soluble in h. acid. A mixture of silicate of alumina, peroxide of iron, and water. Harz, France, and Scotland. Used as a coarse pigment.

123. HALLOYSITE.—$\ddot{A}l$ $\ddot{S}i+4$ $\dot{H}$.

Reniform. H.=1·5...2·5; G.=1·9...2·1. Semitranslucent, and more so when moist. White, inclining to blue, green, or yellow. Adheres slightly to the tongue. B.B. infusible; soluble in c. s. acid. Chem. com. nearly 41·5 silica, 34·4 alumina, and 24·1 water. Liege, Tarnowitz, Thiviers in France; Eifel (*Lenzinite*); Scotland (*Tuesite*).

*124. FULLER'S-EARTH, Walkerde.

Fracture uneven, slaty, or earthy. H.=1...1·5; G.=1·8...2·0. Opaque; dull, but streak resinous. Green, gray, or white. Very greasy; scarcely adheres to the tongue.

Falls down in water, but does not become plastic. That from Reigate in Surrey contained 53 silica, 10 alumina, 9·75 iron peroxide, 1·25 magnesia, 0·5 lime, and 24 water. It is used in preparing cloth,—the best for this purpose being found in England, as at Reigate, Maidstone in Kent, Woburn in Bedfordshire, &c.; also near Maxton in Scotland, in Saxony, Bohemia, and Styria.

125. ALLOPHANE.—$\dddot{A}l\ \ddot{S}i + 5\ \dot{H}$.

Botryoidal and reniform. Fracture conchoidal, brittle. H.=3; G.=1·8...2. Pellucid; vitreous. Pale-blue, white, green, or brown. B.B. intumesces and becomes white, but does not fuse; gelatinizes in acids. Chem. com. often near 24·3 silica, 40·4 alumina, and 35·3 water; occasionally with 2 to 3 oxides of iron or copper and 2 to 4 carbonate of lime or magnesia. Charlton near Woolwich, Baden, Bonn, and Saalfield.

126. SCHRÖTTERITE.—$\dddot{A}l^5\ \ddot{S}i^2 + 20\ \dot{H}$.

Amorphous; conchoidal. H.=3...3·5; G.=2. Greenish, yellowish, or with brown spots. B.B. infusible, but burns white; gelatinizes in h. acid. Freienstein in Styria.

127. BOLE.

Earthy, in nests and veins. Conchoidal. H.=1...2; G.=2·2...2·5. Opaque, or translucent on the edges; dull resinous; streak shining. Brown, yellow, or red. Feels greasy; some adhere strongly to the tongue, others not at all. In water crackle and fall to pieces. B.B. harden, and generally fuse to an enamel; in acids are more or less soluble. Chem. com. hydrous silicates of alumina and iron peroxide in various proportions. Dransfield, Stolpen, Clermont, Auvergne, the trap rocks of the Hebrides and other parts of Scotland, and Ireland. *Sinopite*, red, from Asia Minor, is supposed to be the Sinopian earth of antiquity. *Fettbol*, from Freiberg, and *Ochran*, of a yellow colour, are infusible B.B.

128. TERATOLITE.

Fracture uneven, or earthy. H.=2·5...3; G.=2·5.

Opaque; dull. Lavender-blue to plum-blue, often with reddish-white veins and spots. Feels rough and meagre. B.B. infusible. Schuler's analysis gave 41·66 silica, 22·85 alumina, 12·98 iron peroxide, 3·04 lime, 2·55 magnesia, 0·93 potash, 1·68 manganese peroxide, 14·20 water (=99·89). Planitz near Zwickau; the *Terra miraculosa Saxoniæ* of old authors.

129. KOLLYRITE.—$\ddot{Al}^2\,\ddot{Si} + 10\,\dot{H}$.

Fine-earthy. Fracture even or conchoidal. H.=1...2; G.=2·0...2·15. Semitranslucent or opaque; dull or glimmering. Snow-white, rarely reddish, greenish, or yellowish. Feels greasy, and adheres strongly to the tongue. B.B. infusible; gelatinizes imperfectly with acids. Chem. com. 14 silica, 46 alumina, and 40 water. Schemnitz, Pyrenees, and Saxony. *Scarbroite*, from Scarborough, is similar, but with more (48) water.

130. LITHOMARGE, Steinmark.

Kaolin substances; in general compact, earthy, or pseudomorphous. H.=2·5...3·0; G.=2·4...2·6. Opaque, or dimly translucent; dull. White, yellow, or red. Feel greasy, and adhere more or less to the tongue. Landshut, Clausthal, and the Harz. Similar are *Carnat*, fine red; and *Myelin*, pale yellow or red, and reniform; both from Rochlitz in Saxony: also *Melopsite*, yellowish or greenish-white, from Neudeck in Bohemia.

131. MILOSCHIN, Serbian.—$(\ddot{Al}, \ddot{Cr})\,\ddot{Si} + 3\,\dot{H}$.

Fracture conchoidal, or earthy. H.=2; G.=2·13. Indigo-blue to celadine-green. Adheres to the tongue, and crackles in water. B.B. infusible; partially soluble in h. acid. Contains 3·6 chrome oxide. Rudnaik in Servia.

132. KEROLITE.—$4\,\dot{Mg}\,\ddot{Si} + \ddot{Al}\,\ddot{Si} + 15\,\dot{H}$.

Reniform. Uneven, conchoidal, or splintery; rather brittle. H.=2...3; G.=2·3...2·4. Translucent; dull resinous. White, inclining to gray, yellow, green, or red. Feels greasy, but does not adhere to the tongue. B.B. infusible. Frankenstein in Silesia.

133. AGALMATOLITE, Figure-stone, Pagodite. } $4\,\ddot{Al}\,\ddot{Si}^2 + \dot{K}\,\ddot{Si}^3 + 3\,\dot{H}$.

Massive or slaty. Fracture splintery; rather sectile. H.=2...3; G.=2·8...2·9. Translucent, or only on the edges; dull or glimmering. Green, gray, red, and yellow. Feels somewhat greasy, but does not adhere to the tongue. B.B. burns white and fuses slightly on very thin edges; soluble in warm s. acid. Chem. com. 55 silica, 33·1 alumina, 7·6 potash, and 4·4 water, with 0·5 to 3 iron peroxide, and 0 to 3 lime. China, where it is cut into various works of art; also Nagyag in Hungary, and Saxony. *Cimolite*, pure white clay from Argentiera and Milo, used for cleaning cloth, is similar.

134. SOAPSTONE, Saponite.—$6\,\dot{Mg}\,\ddot{Si} + \ddot{Al}\,\ddot{Si} + 5\,\dot{H}$.

Massive; sectile and very soft. H.=1·5; G.=2·26. White, or light-gray, yellow, and reddish-brown; streak shining. Feels greasy, and writes feebly; does not adhere to the tongue. B.B. fuses to a colourless porous glass; soluble in s. acid. Chem. com. 50 silica, 11·8 alumina, 27·8 magnesia, and 10·4 water. Lizard Point and St Clear in Cornwall, and Dalarne in Sweden (*Piotine*).

135. ONKOSIN.—$2\,\ddot{Al}\,\ddot{Si}^2 + (\dot{K}, \dot{Mg})\,\ddot{Si}^2 + 2\,\dot{H}$.

Fracture uneven or splintery; sectile. H.=2; G.=2·8. Translucent; slightly resinous. Apple-green or brown. B.B. intumesces and fuses; soluble in s. not in h. acid. Salzburg.

136. PIPESTONE.—$(\ddot{Al}, \ddot{Fe})\,\ddot{Si}^3 + (\dot{Na}, \dot{Ca}, \dot{Mg})\,\ddot{Si} + \dot{H}$.

Compact; fracture earthy; sectile. H.=1·5; G.=2·6. Opaque, dull. Grayish-blue, black, or red (*Catlinite*). B.B. infusible. Used by the North American Indians for pipes.

137. MEERSCHAUM.—$2\,\dot{Mg}^3\,\ddot{Si}^3 + 3\,\dot{H}$.

Fracture fine earthy; sectile. H.=2...2·5; G.=0·8... 1·0 (when moist nearly 2). Opaque, dull. Streak slightly shining. Yellowish and grayish-white. Feels rather greasy, and adheres strongly to the tongue. B.B. contracts, becomes hard, and fuses on the edges; soluble in h. acid,

leaving silica. Chem. com. 62·6 silica, 28·3 magnesia, and 9·1 water; but others give also 0·7 to 2·7 carbonic acid, and 14 hygroscopic water. Asia Minor, Greece, near Madrid and Toledo; Moravia and Wermeland (*Aphrodite*, G. =2·21). Chiefly used in forming heads for tobacco pipes.

138. PIMELITE.—$(\dot{N}i, \dot{M}g)^2 \ddot{S}i^3 + \dot{H}$.

Fracture conchoidal. H. = 2·5; G. = 1·4 (*Alizite*)...2·3. Translucent; dull resinous. Colour apple-green; streak yellowish-white. Feels greasy. B.B. fuses to a slag only on thin edges. With borax shows reaction for nickel (32·66 nickel oxide). Silesia. *Razoumoffskin* is by some united to pimelite, but the variety from Kosemutz in Silesia contained no nickel.

139. DERMATIN.—$(\dot{M}g, \dot{F}e)\ \ddot{S}i + 2\ \dot{H}$.

Reniform. H. = 2·5; G. = 2·136. Resinous. Colour blackish-green; streak yellowish-white. Does not adhere to the tongue. B.B. cracks and becomes black. Waldheim in Saxony.

*FAMILY XI.—GARNET.

Chiefly tesseral. H. = 6...7·5; G. = 3·1...3·8. All fusible and soluble in acids, but not readily, or only after ignition. Mostly highly coloured, and often with fine gem-like lustre; but rarely transparent, mostly translucent or opaque. Are mostly anhydrous silicates of alumina and the earths, coloured by oxides of iron, manganese, and chrome.

Occur imbedded, or in veins and druses, in the older crystalline rocks, but rarely as essential constituents.

**140. GARNET.—$\dot{R}^3 \ddot{S}i^2 + \dddot{R} \ddot{S}i$, *or* $\dot{R}^3 \ddot{S}i + \dddot{R} \ddot{S}i$.

Tesseral; most common forms ∞O (fig. 3), and $2O2$ (fig. 6). These are often combined (figs. 18 and 19). Also granular or compact. Cleavage dodecahedral, but very imperfect; fracture conchoidal, or uneven and splintery.

H. = 6·5...7·5; G. = 3·5...4·3. Pellucid in all degrees; vitreous or resinous. Rarely colourless or white; generally red, brown, black, green, or yellow. B.B. in general fuse easily to a glass, black or gray in those containing much iron, green or brown in the others, and often magnetic; imperfectly soluble in h. acid, some wholly, after long digestion, leaving the silica in powder. Chem. com. exceedingly variable, but generally form two series, according as $\ddot{\dot{R}}$ is chiefly alumina or chiefly iron peroxide; and these are again divided according as $\dot{R}$ is more especially lime, iron protoxide, magnesia, or similar bases.

The more important varieties are:—

(1.) *Almandine*, or *Noble Garnet.*—Columbine-red inclining to violet, blood-red, or reddish-brown; streak white; transparent or translucent; sometimes magnetic. Is an iron-alumina garnet, $\dot{Fe}^3\ \ddot{Si}^2 + \ddot{\dot{Al}}\ Si$, with 37 silica, 20·1 alumina, and 42·9 iron protoxide. Common in the primary rocks, in crystals, or rarely forming beds and veins. The finest are from Pegu, Ceylon, and the East. Large crystals at Fahlun, Arendal, Kongsberg, the Tyrol, the Ural, and in North America. It is common in the mica-slates of Perth, Inverness, and Zetland; in granite at Rubislaw near Aberdeen. Used as an ornamental stone.

(2.) *Manganese-alumina Garnet;* $\dot{R} = \dot{Mn}$; reddish-brown; Spessart, Sweden.

(3.) *Lime-alumina Garnets.*—$\dot{Ca}^3\ \ddot{Si}^2 + \ddot{\dot{Al}}\ \ddot{Si}$, with 40·7 silica, 22·5 alumina, and 36·8 lime. To these belong—

(*a.*) *Grossular.*—White to olive-green, and translucent. Wilui River in Siberia, the Ural, and Tellemark in Norway.

(*b.*) *Cinnamon-stone, Hessonite,* or *Kaneelstein.*—Hyacinth-red to honey or orange-yellow, and transparent or translucent. Ceylon and Wermeland. *Romanzowite,* Kimito in Finnland, is similar. When polished, this variety is often named Hyacinth.

(*c.*) *Common Lime-garnet.*—Red, brown, yellow, or green,

and with part at least of the alumina replaced by iron peroxide. Abundant in Piedmont, Vesuvius, the Ural, and North America.

(4.) *Magnesia-garnet.*—$\dot{R}$ chiefly magnesia; opaque, resinous; coal-black. G. = 3·157. Arendal.

(5.) *Iron-garnets.*—$\dot{C}a^3\ \ddot{S}i^2 + \ddot{F}e\ \ddot{S}i$, with 36·2 silica, 31·1 iron peroxide, and 33·6 lime. G. = 3·7...4. More difficultly fusible and more easily soluble in h. acid than the others.

(*a.*) *Common Iron-garnet, Rothoffite, Allochroite.*—Subtranslucent or opaque. Green, brown, yellow, or black, with white, gray, or yellow streak. Sweden and Arendal.

(*b.*) *Melanite.*—Black; opaque; in thin splinters translucent. Streak gray; slightly magnetic. Albano near Frascati, Vesuvius, France, Lappmark. *Pyreneite*, near Barèges in the Pyrenees.

(*c.*) *Colophonite.*—Yellowish-brown to pitch-black, also yellow or red; resinous; streak white. G. = 3·43. Arendal.

(6.) *Uwarowite*, or *Chrome-garnet.*—Emerald-green; vitreous; streak greenish-white. Translucent or only on the edges. G. = 3·4; H. = 7·5. B.B. infusible, contains 22 to 23·5 chrome-peroxide. Bissersk and Kyschtimsk in Ural.

141. PYROPE.—$(\dot{M}g, \dot{F}e, \dot{C}a, \dot{M}n)^3\ \ddot{S}i^2 + \ddot{A}l\ \ddot{S}i$.

Tesseral, but crystals (cubes) rare and indistinct; generally in roundish grains. Cleavage not perceptible; fracture conchoidal. H. = 7·5; G. = 3·7...3·8. Transparent or translucent; vitreous. Dark-hyacinth to blood-red. B.B. becomes black and opaque, but regains its colour and transparency on cooling; fuses with difficulty to a black glass. Not soluble in acids, partially after fusion. Chem. com. 41·35 silica, 22·35 alumina, 15 magnesia, 9·94 iron protoxide, 5·29 lime, 4·17 chrome-protoxide, and 2·58 manganese-protoxide (*Moberg*). The chrome has also been considered as the oxide or acid. Zöblitz in Saxony, Meronitz

and Mittelgebirge in Bohemia, and Elie in Fife (Elie rubies). Valued as a gem.

142. HELVINE. $\begin{cases} \text{Mn S} + 3\,\dot{R}^2\,\ddot{S}i, \textit{ or} \\ \text{Mn S, Mn O} + (\dot{M}n, \dot{F}e)^3\,\ddot{\dddot{S}}i^2 + \dot{G}\,\ddot{\dddot{S}}i. \end{cases}$

Tesseral, and tetrahedral; $\frac{O}{2}$ or $\frac{O}{2} \cdot -\frac{O}{2}$ (fig. 128).

Imbedded or attached. Cleavage, octahedral imperfect. H. = 6...6·5; G. = 3·1...3·3. Translucent on the edges; vitreous to resinous. Wax-yellow, siskin-green, or yellowish-brown. B.B. in the red. flame fuses with intumescence to a yellow obscure pearl; soluble in h. acid, evolving sulphuretted hydrogen, and gelatinizes. Chem. com. 34 silica, 10 glucina, 8 iron protoxide, 43 manganese protoxide, and 5 sulphur. Schwarzenberg in Saxony, and near Modum in Norway.

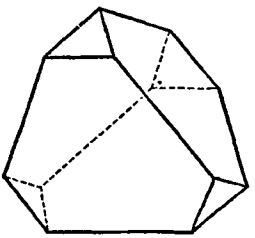


Fig. 128.

143. IDOCRASE, Vesuvian. $\begin{cases} 3\,(\dot{C}a, \dot{M}g, \dot{F}e)^3\,\ddot{S}i + 2\,\ddot{\dddot{A}}l\,\ddot{\dddot{S}}i^2, \textit{ or} \\ 3\,(\dot{C}a, \dot{M}g, \dot{F}e)^3\,\ddot{\dddot{S}}i + 2\,(\ddot{\dddot{A}}l, \ddot{\dddot{F}}e)\,\ddot{\dddot{S}}i. \end{cases}$

Tetragonal; P 74° 27′. Crystals of ∞P, ∞P∞, 0P, P, P∞ (56° 29′), ∞P3. Columnar; more rarely tabular or

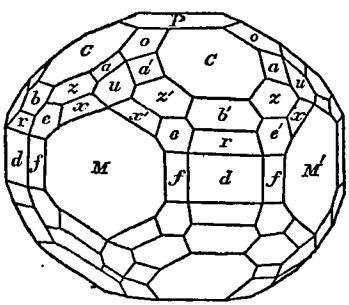


Fig. 129.

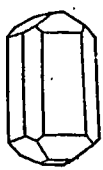


Fig. 130.

pyramidal (figs. 129, 130). Also columnar or granular.

Cleavage, prismatic along $\infty P\infty$ and ∞P, but imperfect; fracture uneven, splintery. H.=6·5; G.=3·35...3·45 (or 4). Pellucid; vitreous or resinous. Yellow, green, brown, almost black, rarely azure-blue; streak white. B.B. fuses easily with intumescence to a yellowish-green or brown glass; partially soluble in h. acid, after fusion wholly, and gelatinizes. Chem. com. 39 silica, 22 alumina, 32 lime, 5 iron protoxide, and 2 magnesia. Vesuvius, Wilui River in Siberia, Mussa-alp in Piedmont, Egg in Norway, Wicklow in Ireland, Monaltrie in Aberdeenshire, and near Broadford in Skye, in Scotland.

Gahnite, Loboite, Gökumite, from Gökum; *Frugardite*, from Finnland; *Egeran*, from near Eger; *Cyprine*, from Tellemark, Norway (azure-blue or green, contains copper, and B.B. melts easily in the inner flame to a red pearl); *Xanthite*, from Amity in New York—seem only idocrase.

Used as an ornamental stone, the brown being named hyacinth, the green chrysolite, but it is not highly valued.

*144. EPIDOTE. $\left\{\begin{array}{l}(\dot{Ca}, \dot{Mg}, \dot{Fe})^3\ \ddot{Si}^2+2\,(\ddot{Al}, \ddot{Fe}, \ddot{Mn})\,\ddot{Si} \\ \textit{or}\ \dot{R}^3\,\ddot{Si}+2\,\ddot{R}\,\ddot{Si}.\end{array}\right.$ (*Rams.*)

Monoclinohedric; C=89° 27′, $\infty P2$ 63° 8′, $P\infty$ 64° 36′, $-P\infty$ 63° 43′, P 70° 9′, $-P$ 70° 33′. Crystals horizontal-prismatic, as in fig. 131, where $\infty P\infty$ (*M*). $P\infty$ (*T*). $-P\infty$ (*r*). $-P$ (*n*). Generally in druses; the surface often horizontally striated. Macles united by a face of $P\infty$; also columnar, granular, or compact. Cleavage, orthodiagonal very perfect, along $P\infty$ rather perfect; fracture conchoidal, uneven, or splintery. H.=6...7; G.=3·2...3·5. Pellucid in all degrees; vitreous, on cleavage adamantine. Especially green, yellow, and gray; rarely red and black. B.B. fusible; strongly ignited, or after fusion all are soluble in h. acid, and gelatinize. Varieties are,—

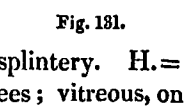


Fig. 131.

(1.) *Zoisite.*—White, yellowish, or brownish-gray; chiefly

large imbedded crystals, or foliated and columnar. B.B. intumesces and forms a white or yellow porous mass, and on the edges fuses to a clear glass. Is a lime-alumina epidote, = 42·4 silica, 31·4 alumina, 26·2 lime, with very little iron oxide or magnesia. Sau Alpe in Carinthia, the Ural, and Connecticut. *Thulite*, rose or peach-blossom red, from Souland in Norway, is similar.

(2.) *Pistazite, Thallite.*—Pistacio-green to blackish-green and black, also yellow or brown. Crystallized, granular, or earthy, also in crusts. B.B. fuses on the edges, and swells into a dark-brown slag. Is an iron-epidote, with 10 to 16 peroxide and 2 to 6 protoxide of iron. Arendal, the Ural, the Alps (Mont Blanc), Pyrenees, the Harz, Finnland, Greenland, and North America. In Scotland, in syenite in Zetland, in gneiss in Sutherland, in trap in Mull and Skye, in quartz in Rona, in clay-slate in Arran, and in porphyry in Arran and Glencoe. *Puschkinite*, from the Ural; *Withamite*, from Glencoe, in minute bright-red crystals; and *Bucklandite*, in small black crystals, from Lake Laach and Siberia, are this variety.

(3.) *Manganese-epidote.*—With much manganese-peroxide (14 to 20). Dark violet-blue or reddish-black; streak cherry-red. H. = 6·5; G. = 3·4. B.B. melts easily to a black glass. St Marcel in Piedmont.

*145. AXINITE. $\begin{cases} 2\,(\dot{C}a, \dot{M}g)^2\,\ddot{S}i^3 + 3\,(\ddot{A}l, \ddot{F}e, \ddot{M}n)\,Si + \\ (\dot{C}a, \dot{M}g)\,\ddot{B}, \textit{ or} \\ 2\,[2\,\dot{R}\,\ddot{S}i + \dot{R}^3\,\ddot{S}i] + \ddot{B}\,\ddot{S}i. \end{cases}$

Triclinohedric. Crystals usually very unsymmetrical (figs. 132 and 133), with u to P = 135° 24′, u to r = 115° 39′, P to r = 134° 48′; attached singly, or in druses. Also laminar or broadly radiated. Cleavage, imperfect along a plane truncating the sharp edge between P and u. H. = 6·5...7; G. = 3...3·3. Pellucid; vitreous. Clove-brown, inclining to smoke-gray or plum-blue, but often cinnamon-brown in one direction, dark violet-blue in a second, and

pale olive-green in a third. B.B. intumesces and fuses easily to a dark-green glass, becoming black in the ox. flame;

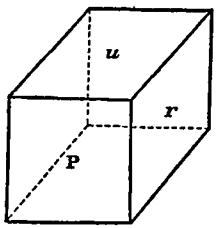


Fig. 132.

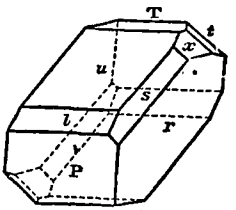


Fig. 133.

not soluble in h. acid till after ignition, when it gelatinizes. Chem. com. about 44 silica, 5 boracic acid, 16 alumina, 11 iron peroxide, 1·5 manganese-peroxide, 2·5 magnesia, and 20 lime. Bourg d'Oisans in Dauphiné, and the Botallack mine in Cornwall, Kongsberg in Norway, Arendal, Nordmark in Sweden, Pyrenees, Savoy, Tyrol, Thum in Saxony (*Thummerstein*), the Ural, and North America.

146. GLAUCOPHANE. $\begin{cases} 2\,\dddot{A}l\,\ddot{S}i^3 + 9\,(\dot{F}e, \dot{N}a, \dot{M}g, \dot{C}a, \\ \dot{M}n)\,\ddot{S}i. \end{cases}$

Rhombic or monoclinohedric, only indistinct; thin four or six-sided prismatic crystals, or granular. Cleavage, prismatic distinct; fracture conchoidal. H. = 5·5; G. = 3·1. Translucent or opaque; vitreous or pearly. Gray, indigo-blue, or bluish-black. B.B. becomes yellowish-brown, and fuses readily to an olive-green glass; partly soluble in acids. Island of Syra. Similar are,—

Wichtyne.—Massive; black. B.B. fuses to a black enamel; not affected by acids. Wichtis in Finnland.

Violan.—Massive; opaque, resinous. Dark violet-blue. B.B. fuses easily to a clear glass. St Marcel in Piedmont.

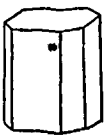
FAMILY XII.—CYANITE.

Triclinohedric or rhombic, often in long prismatic forms. H. = 5...7·5; G. = 2·9...3·8. B.B. infusible; insoluble in acids. Some show fine colours and high vitreous lustre.

They are chiefly anhydrous silicates of alumina. Occur especially in the crystalline strata.

*147. CYANITE, Disthene.—$\dot{\ddot{A}}\dot{S}i$, *or* $\dot{\ddot{A}}l^3\,\dot{S}i^2$.

Triclinohedric. Generally broad prismatic lengthened crystals formed by two faces meeting at 106° 16′. Macles are common, united by $\infty P\infty$. Also even, curved, or radiated. Cleavage, along the prisms very (or less) perfect; brittle. H.=5 on cleavage planes, on other faces=7; G.=3·5 ...3·7. Pellucid, vitreous; on cleavage pearly. Colourless, or blue, gray, green, yellow, or red. Not affected by acids. B.B. infusible. Chem. com. 37·6 silica, and 62·4 alumina. St Gotthardt, Tyrol (*Rhætizite*), Pontivy in France, Bohemia, Nigg near Aberdeen, Botriphny in Banffshire, and Hillswick in Zetland.

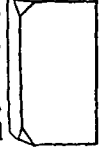

Fig. 134.

148. SILLIMANITE.—$\dot{\ddot{A}}\dot{S}i$.

Triclinohedric, with $\infty P' : \infty'P = 98°$, $P' : \infty P' = 105°$. Crystals long and slender; also fibrous or parallel. Cleavage, macrodiagonal highly perfect. H.=7...7·5; G.=3·2 ...3·26. Translucent; vitreous, inclining to pearly. Grayish-brown, clove, or hair-brown. B.B. infusible; not affected by acids. Chem. com. like cyanite, from which it is scarcely distinct. Chester and Norwich in Connecticut, Tvedestrand in Norway. The *Xenolite*, Finnland; *Bucholzite*, *Fibrolite*, and *Bamlite*, from Bamle in Norway, seem also cyanite; *Wörthite*, an altered variety.

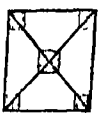
*149. ANDALUSITE.—$\dot{\ddot{A}}\dot{S}i$, *or* $\dot{\ddot{A}}l^3\,\dot{S}i^2 = \dot{\ddot{A}}l^4\,\dot{S}i^3$.

Rhombic; ∞P 90° 44′, $\breve{P}\infty$ 109° 6′. Crystals $\infty P \cdot 0P$, or this with $\breve{P}\infty$ (fig. 135); prismatic, attached or imbedded; also columnar, or granular. Cleavage, ∞P rather indistinct; traces along $\infty\breve{P}\infty$, $\infty\bar{P}\infty$, and $\bar{P}\infty$; fracture uneven, splintery. H.=7... 7·5; G.=3·1...3·3. Pellucid; vitreous. Gray, green, red, or blue. B.B. infusible; not affected by acids. Chem. com. 40·4 silica and 59·6 alu-


Fig. 135.

mina, with 1 to 2 iron peroxide. Andalusia, Lisens in Tyrol, Penig in Saxony, Westford in Massachusetts, Litchfield in Connecticut; and Botriphny in Banffshire, Tyrie in Aberdeenshire, and Killiney Bay in Wicklow.

Chiastolite.—H. = 5...5·5; G. = 3. Dirty or pale gray, yellow, or red. Occurs imbedded in clay-slate, and often appears like four crystals separated by a black cross (fig. 136). Fichtelgebirge, Brittany, the Pyrenees, Sierra Morena, Wolfscrag near Keswick, and on Skiddaw in Cumberland; near Balahulish in Argyleshire, Boharm in Banffshire, and in Wicklow.


Fig. 136.

*150. STAUROLITE, Staurotide. $\begin{cases} (\dot{\ddot{A}}l, \dot{\ddot{F}}e)^4 \ddot{S}i^3 = \dot{\ddot{R}}^2 \ddot{S}i, \textit{or} \\ (\dot{\ddot{A}}l, \dot{\ddot{F}}e)^5 \ddot{S}i^6. \end{cases}$

Rhombic; ∞P 128° 42′, $\breve{P}\infty$ 70° 46′. Crystals ∞P (*M*). $\infty\breve{P}\infty$ (*o*). 0P (*P*). Macles very common, like figs. 137 or 138. Cleavage, brachydiagonal perfect, traces along ∞P;

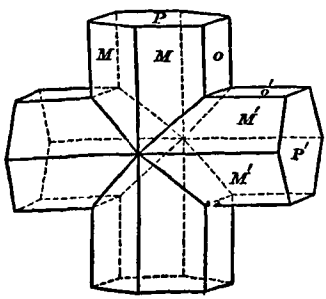


Fig. 137.

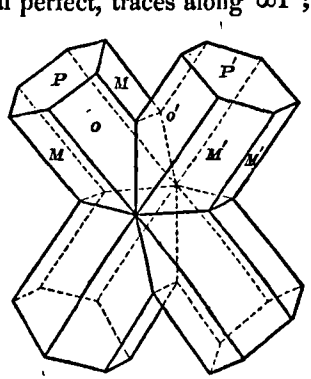


Fig. 138.

fracture conchoidal, or uneven and splintery. H. = 7; G. = 3·5...3·8. Translucent or opaque; vitreous, inclining to resinous. Reddish to blackish-brown; streak white. B.B. infusible; not affected by h.; partially by s. acid. Chem. com. ranges from 28 to 40 silica, 45 to 55 alumina, 15 to 18 iron peroxide, with 0·2 to 2·5 magnesia. St Gotthardt and Greiner in Tyrol, Finisterre, Pyrenees, Spain, the Ural,

and in North America; in Scotland, Bixeter Voe in Zetland, in Aberdeenshire, and the Hebrides.

151. DIASPORE.—$\ddot{A}\dot{H}$.

Rhombic; $\infty P = 130°$, broad indistinct prisms, chiefly of $\infty\breve{P}\infty$, bounded by the curved faces of P (fig. 139). Usually thin foliated or broad radiated. Cleavage, brachydiagonal highly perfect; very brittle. H. = 6; G. = 3·3...3·4. Pellucid; vitreous; pearly on $\infty\breve{P}\infty$. Colourless, but generally yellowish or greenish-white; also violet-blue. Insoluble in acids. B.B. infusible, but some decrepitate into small white scales. Chem. com. 85 alumina and 15 water. Rare. The Ural, Schemnitz, Broddbo, and St Gotthard.

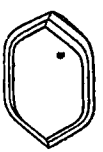


Fig. 139.

152. HYDRARGILLITE.—$\ddot{A}\dot{H}^3$.

Hexagonal; 0P. $\infty P . \infty P2$, or granular scaly. Cleavage, basal very perfect. H. = 2·5...3; G. = 2·3...2·4. Translucent; vitreous; pearly on 0P. Colourless or reddish-white. Slowly soluble in warm acids. B.B. exfoliates, and gives out a strong light, but is infusible. Chem. com. 65·5 alumina and 34·5 water. Near Slatoust in the Ural. Stalactitic, greenish or grayish-white (*Gibbsite*); Richmond in Massachusetts, and Villa Rica in Brazil.

153. PERICLASE.—$\dot{M}g$.

Tesseral, only in octahedrons. Cleavage, hexahedral perfect. H. = 6; G. = 3·75. Transparent; vitreous. Dark-green. B.B. infusible; powder soluble in acids. Chem. com. magnesia, with 5 to 8 protoxide of iron. Monte Somma.

FAMILY XIII.—GEMS.

All very hard, H. = 7...9, or scratch quartz, except a few $=6$, which are scarcely true gems; G. = 2·6...4·7, but mostly high in the finest. Insoluble in acids, and infusible B.B. in the true gems. These have a high lustre, brilliant colours, and take a fine polish, and are therefore much valued. They

are, however, rare, and generally small. Chem. com. variable, but mostly simple. Chiefly occur in the older igneous or metamorphic rocks.

*154. ZIRCON.—$\dot{Z}r^2\,\ddot{S}i$, *or* $\dot{Z}r^3\,\dddot{S}i$, *or* $\dddot{Z}r\,\dddot{S}i$.

Tetragonal; P 84° 20′. Crystals, ∞P. P, often with 3P3; also ∞P∞ . P, or ∞P∞ (*s*) . ∞P (*l*) . P (*P*) . 3P3 (*x*) . P∞ (*t*) . 4P4 (*y*) . 5P5 (*z*) (fig. 140), chiefly prismatic or pyramidal, and in rounded grains. Cleavage, along P and ∞P, both rather imperfect; fracture conchoidal or uneven. H.=7·5; G. =2...4·7. Transparent to opaque; vitreous, often adamantine. Rarely white, generally gray, yellow, green, or frequently red and brown. B.B. loses its colour, but is infusible; not affected by any acid except con. s. acid, after long digestion. Chem. com. 66·23 zirconia (and noria, *Svanberg*), and 33·77 silica, with 0 to 2 iron peroxide as colouring matter. Southern Norway, Ilmen Mountains, Arendal, Sweden, Carinthia, Tyrol, Ceylon, and North America; in Scotland, at Scalpay in Harris, and Criffel.

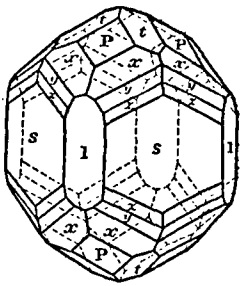


Fig. 140.

The colourless varieties are often sold for diamonds. The more brilliantly coloured are named hyacinth.

155. MALAKON.—3 $\dot{Z}r^2\,\ddot{S}i + \dot{H}$.

Tetragonal; P. 82°. Crystals like zircon. H.=6; G. =3·9. Opaque; resinous or vitreous. Internally bluish-white, but on the surface mostly brownish, reddish, yellowish, or blackish. Chem. com. zircon, with 3 per cent. water. Hitterö in Norway. *Malakon*, *Œrstedtite* from Arendal, *Tachyaphaltite* from Krageroe, and *Calyptolite*, are all probably altered zircon.

*156. SPINEL.—$\dot{M}g\,\dddot{A}l$, *or* $(\dot{M}g, \dot{F}e)\,(\dddot{A}l, \dddot{F}e)$.

Tesseral; O, alone or predominating, ∞O and 3O3.

Macles united by a face of O (fig. 141); also in grains or fragments. Cleavage, octahedral imperfect; fracture conchoidal. H.=8; G.=3·4...3·8. Transparent to opaque; vitreous. Red, blue, green, and black; streak white. B.B. infusible and unchanged. Chem. com. 71 alumina and 29 magnesia; but some 1 to 5 silica, 3 to 20 iron protoxide, 0 to 6 iron peroxide, and the red varieties 1 to 5 chrome. The varieties are:—

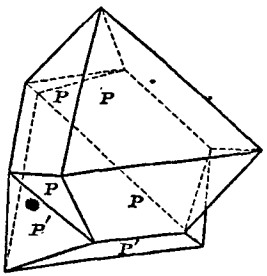


Fig. 141.

Spinel or *Spinel-ruby*, rose-red (*Balas ruby*), yellow or orange-red (*Rubicelle*), violet (*Almandine ruby*), or brown; G.=3·52; from Ceylon, Ava, and the East. Much prized as ornamental stones. *Sapphirine*, pale sapphire-blue to greenish or reddish blue; G.=3·4...3·7; with 4 per cent. iron protoxide; Aker in Sweden, Greenland, and North America. *Pleonaste*, opaque or translucent, black; G.=3·65...3·8; with 8 to 20 iron protoxide; Candy in Ceylon (*Candite*, or *Zeilanite*), Monte Somma, Monzoni, Arendal, Bohemia (*Hercinite*), the Ural, and New York. *Chlorospinel*, grass-green, with a yellowish-white streak; G.=3·59; Slatoust in the Ural.

157. AUTOMOLITE, Gahnite.—$\dot{Z}n\,\ddot{\ddot{A}}l$.

Tesseral; O, alone or macled. Cleavage, O perfect; brittle, with conchoidal or splintery fracture. H.=8; G.=4·3...4·6. Opaque or translucent on the edges; vitreous, inclining to resinous. Dark leek-green to blackish-green and blue; streak gray. B.B. unchanged; not affected by acids or alkalis. Chem. com. 56 alumina and 44 zinc oxide, but with 4 to 6 protoxide of iron, and 2 to 5 magnesia. Fahlun, Broddbo, Haddam in Connecticut, and Franklin in New Jersey. *Dysluite*, yellowish-brown, with manganese, from Sterling, Massachusetts; and *Kreittonite*, brown, from Bodenmais, are similar.

*158. CORUNDUM.—$\dot{A}\dddot{l}$.

Rhombohedric; isomorphous with peroxides of iron and chrome; R 86° 4'. Crystals chiefly of ∞P2 (*s*), 0R (*o*), R (*P*), are pyramidal (fig. 142), prismatic (fig. 143), or

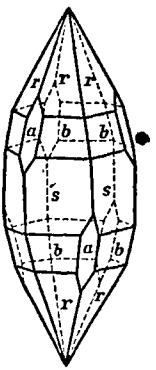


Fig. 142.

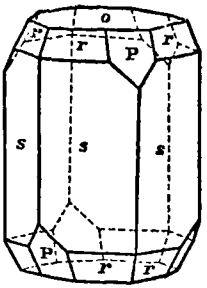


Fig. 143.

rhombohedral. Macles common, united by a face of R. Cleavage, rhombohedral along R, or basal. Extremely tough, and difficultly frangible. H.=9; G.=3·9...4·2. Transparent or translucent; vitreous, or pearly on 0R. Colourless and white, but generally blue, red, yellow, brown, or gray. B.B. unchanged. Chem. com. alumina, with a minute proportion of peroxide of iron or other colouring matter.

Varieties are:—(1.) *Sapphire*, highly transparent, very imperfect cleavage and conchoidal fracture; colourless, blue (*Salamstein*), seldomer green, yellow, red (*Oriental rubies*), or brown; Ceylon, Ava, Pegu, Miask, Slatoust, Bilin in Bohemia, and Expailly in Auvergne. (2.) *Corundum*, rough crystals or foliated, less transparent and duller colours; Malabar, Ceylon, Ava, Canton in China, Siberia, St Gotthardt, and Piedmont. Some (*Asteria* or *star sapphire*) show a bright opalescent star of six rays. (3.) *Adamantine spar*, with distinct cleavage, hair-brown, and adamantine; Gellivara, Ural, Malabar, and North America. (4.) *Emery*, compact, dimly translucent, and gray or indigo-

blue; Asia Minor near Smyrna, Naxos, Spain, Saxony, and Greenland. Sapphire and rubies are highly valued as ornamental stones; emery as a polishing material.

159. CHRYSOBERYL, Cymophane. } $\ddot{G}\,\ddot{A}l^3$.

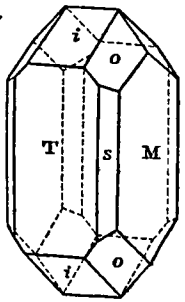


Fig. 144.

Rhombic; P with polar edges 86° 16′ and 139° 53′. Crystals of $\infty\breve{P}\infty$ (*M*) . $\infty\breve{P}\infty$ (*T*) . $\breve{P}\infty$ (*i*), or this with ∞P3 (*s*), and also with P (*o*) (fig. 144), are short and broadly columnar, or thick tabular with vertical striæ. Macles very common, united by a face of $\breve{P}\infty$. Cleavage, brachydiagonal imperfect, macrodiagonal more so; fracture conchoidal. H.=8·5; G.=3·68...3·8. Transparent or translucent; vitreous, sometimes resinous. Greenish-white, leek-green, olive-green, and greenish-gray; sometimes with a bluish opalescence, or beautiful dichroism. B.B. infusible; not affected by acids. Chem. com. 80·25 alumina and 19·75 glucina, with 3 to 4 protoxide of iron. Brazil, Ceylon, India, Haddam in Connecticut, and Ural.

*160. TOPAZ. $\left\{\begin{array}{l} 6\,\ddot{A}l\,\ddot{S}i + (\ddot{A}l\,F^3 + Si\,F^2), \textit{ or} \\ 6\,\ddot{A}l^3\,\ddot{S}i^2 + (3\,\ddot{A}l\,F^3 + 2\,Si\,F^3). \end{array}\right.$

Rhombic; ∞P (*M*) 124° 19′, $2\breve{P}\infty$ (*n*) 93°, $\infty\breve{P}2$ (*l*) 93° 8′, P (*o*), and numerous other forms. Crystals always prismatic (fig. 145), often hemimorphic, and the prisms finely striated; also granular. Cleavage, basal very perfect, traces in other directions, especially *M* and *l* in the Scottish varieties; fracture conchoidal or uneven. H.=8; G.=3·4...3·6. Transparent to translucent on the edges; vitreous. Colourless, but yellowish, reddish, or greenish white, honey-yellow, hyacinth-red, violet-blue, and asparagus-green. Becomes

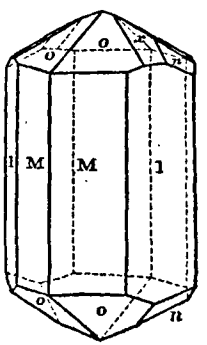


Fig. 145.

electric from heat or friction. B.B. infusible. Not affected by h. acid, but by long digestion in s. acid gives traces of fluorine. Chem. com. 35·52 silica, 53·33 alumina, and 17·49 fluorine (= 108·33). Brazil, Siberia, Ceylon, New Holland, Peru, Connecticut, Bohemia, Saxony, and Cornwall (St Michael's Mount), Mourne Mountains in Ireland, Cairngorum Mountains in Aberdeenshire (one crystal nineteen ounces). The common or coarse columnar named *Pyrophysalite*, at Finbo, and Broddbo near Fahlun. Topaz is valued as an ornamental stone. The purest from Brazil, when cut in facets like the diamond, closely resemble it in lustre and brilliance, but are easily known by their electricity.

161. PYCNITE, Schorlite.—$\dddot{Al}^5\,\ddot{Si}^6 + (\dddot{Al}\,F^3 + Si\,F^2)$.

Massive; like topaz. H. = 7·5; G. = 3·49...3·54. Translucent; vitreous. Straw-yellow to reddish-white. Chem. com. 39·04 silica, 51·25 alumina, 18·48 fluorine. Altenberg in Saxony, and Schlackenwald and Zinnwald in Bohemia.

162. LEUCOPHANE.—$3\,\dot{Ca}\,\ddot{Si} + \dddot{G}\,\ddot{Si}^2 + Na\,F$.

Triclinohedric; but crystals rare. Cleavage in three directions, intersecting at 53° 25′ and 65°. H. = 3·5...4; G. = 2·974. In thin splinters pellucid and almost colourless; in thicker pieces wine-yellow or olive-green; vitreous or resinous. B.B. fuses to a pale violet-blue bead. Near Brevig in Norway.

163. EUCLASE.—$3\dddot{Al}\,\ddot{Si} + \dddot{G}^3\,\ddot{Si}^4$.

Monoclinohedric; C. = 71° 7′; ∞P 115°, P 105° 49′. Crystals ∞P (*s*) . (∞P∞) (*T*) . P (*f*) (fig. 146). Cleavage, clinodiagonal highly perfect, along P∞ less so; ∞P∞ in traces. Very brittle and fragile; fracture conchoidal. H. = 7·5; G. = 3...3·1. Transparent; splendent vitreous. Pale mountain-green, passing into yellow, blue, or white. B.B. intumesces, becomes white, and melts in thin splinters to a white enamel. Not affected by acids. Chem.

com. 44·7 silica, 31·8 alumina, and 23·5 glucina, with 1 to 2·2 iron peroxide and 0·4 to 0·7 tin oxide. Peru and Brazil, but very rare.

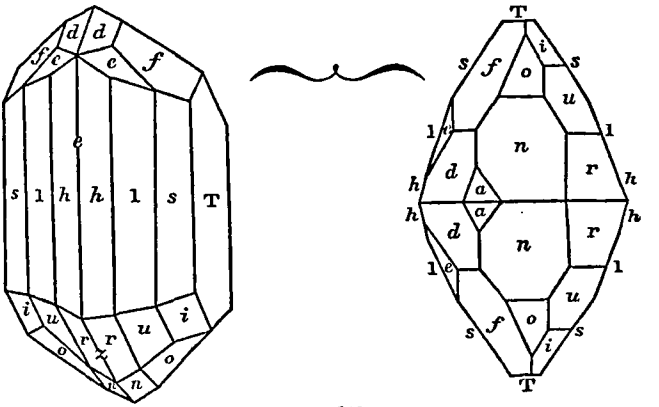


Fig. 146.

*164. EMERALD, BERYL. $\begin{cases} \dddot{\mathrm{Al}}\,\ddot{\mathrm{Si}}^3 + \dddot{\mathrm{G}}\,\ddot{\mathrm{Si}}^3, \textit{ or} \\ \dddot{\mathrm{Al}}\,\ddot{\mathrm{Si}}^2 + \dddot{\mathrm{G}}\,\ddot{\mathrm{Si}}^2. \end{cases}$

Hexagonal; P 59° 53′. Crystals of ∞P . 0P, and ∞P . ∞P2 . 0P (fig. 147), are prismatic, generally with vertical striæ. Cleavage, basal rather perfect, ∞P imperfect. H. = 7·5...8; G. = 2·6...2·8. Transparent or translucent; vitreous. Colourless or white, but generally green, sometimes very brilliant, also yellow, and smalt-blue. B.B. melts with difficulty on the edges to an obscure vesicular glass; not affected by acids. Chem. com. 67·5 silica, 18·7 alumina, and 13·8 glucina, with 0·3 to 3 iron peroxide, and 0·3 to 3·5 chrome oxide in the rich green emerald. *Emerald*, bright green; G. = 2·710... 2·759; occurs in Muso Valley near Bogota, also in Salzburg and the Ural. *Beryl*, or *Aquamarine*, colourless, or less brilliant; G. = 2·577...2·725; near Mursinsk, and Nertschinsk in Siberia, Salzburg and Brazil; in the United States.

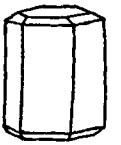


Fig. 147.

at Ackworth in New Hampshire, Royalston in Massachusetts, Haddam in Connecticut; Mourne Mountains in Ireland, and Cairngorum Mountains in Aberdeenshire. *Common beryl* at Fahlun in Sweden, Fossum in Norway, Limoges in France, Rabenstein in Bavaria, Rubislaw near Aberdeen (*Davidsonite*). Emerald and beryl are much valued as precious stones.

165. PHENAKITE.—$\dddot{G}^2\,\ddot{S}i^3$.

Rhombohedric; R 116° 40′. Crystals R . ∞P2, or ∞P2 . $\frac{2}{3}$P2 . R. (fig. 148). Macles with parallel axes and intersecting. Cleavage, R and ∞P2 not very distinct; fracture conchoidal. H. = 7·5... 8; G. = 2·97. Transparent or translucent; vitreous. Colourless, and wine-yellow or brown. B.B. infusible; not affected by acids. Chem. com. 55 silica, and 45 glucina. Ural, Ilmen Mountains, Framont in Alsace.

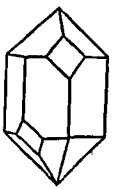


Fig. 148.

*166. CORDIERITE, Iolite, Dichroite. $\begin{cases} \ddot{A}l^2\,\ddot{S}i^3 + 2\,(\dot{M}g,\,\dot{F}e)\,\ddot{S}i, \text{ or} \\ 3\,\ddot{A}l\,\ddot{S}i + \dot{R}^3\,\ddot{S}i^2. \end{cases}$

Rhombic; ∞P 119° 10′, middle edge of P 95° 36′. Crystals ∞P (*T*) . $\breve{\infty}\breve{P}\infty$ (*l*) . 0P (*M*), and this with $\bar{\infty}\bar{P}\infty$ (*k*), $\breve{\infty}\breve{P}3$ (*d*), $\breve{P}\infty$ (*n*), and $\frac{1}{2}$P (*s*) (fig. 149); short, prismatic. Cleavage, $\breve{\infty}\breve{P}\infty$ rather distinct, traces along $\bar{P}\infty$; fracture conchoidal or uneven. H. = 7...7·5; G. = 2·5...2·7. Transparent or translucent; vitreous, inclining to resinous. Colourless, but chiefly blue, green, brown, yellow, and gray, often with distinct pleochroism. B.B. fuses slowly to a clear glass; slightly affected by acids. Chem. com. 48 to 51 silica, 29 to 33 alumina, 8 to 13 magnesia, 1 to 12 iron protoxide, and 0 to 1·5 manganese protoxide. Cabo de Gata in Spain, Bodenmais (*Peliom*), Orrijerfvi (*Steinheilite*), Norway, Sweden, Greenland, North America, and Siberia.

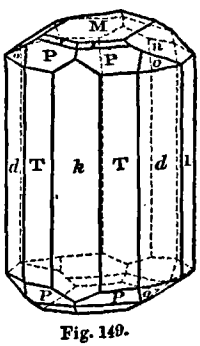


Fig. 149.

Small rolled masses of an intense blue colour and transparent, found in Ceylon, are the *Sapphire d'Eau* or *Luchssapphir* of the jewellers.

The following substances seem cordierite altered, or with 2 to 4 atoms water:—

(*a.*) *Bonsdorfite, Hydrous Iolite,* greenish-brown, or dark olive-green, near Åbo. (*b.*) *Esmarkite, Chlorophyllite,* large prisms or foliated, green or brownish; near Brevig in Norway, Unity in Maine, and Haddam in Connecticut. (*c.*) *Fahlunite, Triclasite,* compact, greenish-brown or black foliated; H.=2·5...3; G.=2·5...2·8; Fahlun. (*d.*) *Weissite,* kidney-shaped and ash-gray or brown; Fahlun and Lower Canada. (*e.*) *Pyrargillite,* indistinct imbedded crystals, black passing into brown or red, dull resinous lustre; H.=3·5; G.=2·5; Helsingfors. (*f.*) *Pinite,* crystallized, or massive and laminar, with imperfect cleavage; H.=2...3; G.=2·7...2.9; semitranslucent or opaque, dull or resinous, and dirty-gray, green, or brown; B.B. fuses to a glass, sometimes clear, at other times dark-coloured; Auvergne, Schneeberg, Penig in Saxony, in the Harz, Cornwall, Aberdeenshire, the United States, and Greenland (*Giesechite*). *Oosite* from Geroldsau in Baden, snow-white, opaque, fragile, is similar. (*g.*) *Gigantolite;* H.=3·5; G.=2·8...2·9; opaque, dull resinous, and greenish-gray or brown; B.B. intumesces slightly, and fuses easily to a greenish slag; Tammela in Finnland. (*h.*) *Praseolite,* lamellar and green; Brevig in Norway.

** 167. TOURMALINE, Schorl.

Rhombohedric; R 133° 10′. Crystals of 0R (*k′*), −½R (155°) (*n*), R (*P*), −2R (103° 3′) (*o*), ∞P2 (*s*), and ∞R (*l*), usually long prismatic, striated, and remarkable for hemimorphism, ∞R appearing as a triagonal prism (figs. 150, 151); also radiating, columnar, or fibrous. Cleavage, R and ∞P 2 both imperfect; fracture conchoidal or uneven. H.=6·5...7·5; G.=3...3·3. The black opaque, the others pellucid; vitreous. Colourless, but gray, yellow, green,

blue, red, brown, and most frequently black. Often several colours in layers perpendicular, or parallel to the axis. By

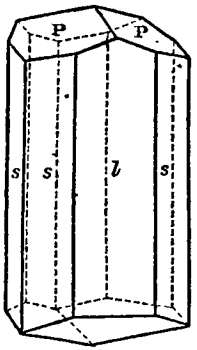


Fig. 150.

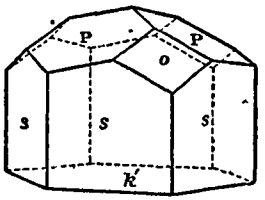


Fig. 151.

friction acquires positive, by heat polar electricity; powder white, often magnetic. B.B. some fuse, others only intumesce, and some both fuse and intumesce. Powder not soluble in h., only imperfectly in s. acid. Chem. com. very complex, with 36 to 41 silica, 5 to 10 boracic acid, 1·3 to 2·7 fluorine, 0 to 0·3 phosphoric acid, 30 to 45 alumina, 0 to 13 iron peroxide, 0 to 5 manganese peroxide, 0 to 10 iron protoxide, 0·5 to 15 magnesia, 0 to 2 lime, 1 to 2·6 soda, 0·1 to 2 potash, and 0 to 1·5 lithia. Rammelsberg makes five groups in two divisions:—

A. Tourmalines with no lithia, and little or no manganese:—

(1.) Magnesia Tourm. $-\dot{R}^3\,\dddot{S}i^2+3\ddot{R}\,\dddot{S}i$; yellow and brown, with much magnesia and little iron.

(2.) Magnesia-iron T. $-\dot{R}^3\,\dddot{S}i^2+4\ddot{R}\,\dddot{S}i$; apparently black, with an average amount of magnesia and iron.

(3.) Iron T. $-\dot{R}^3\,\dddot{S}i^2+6\ddot{R}\,\dddot{S}i$; deep black, with most iron and least magnesia.

B. Tourmalines with lithia and little magnesia:—

(4.) Iron-manganese T. $-\dot{R}\,\ddot{S}i+3\ddot{\dot{R}}\,\ddot{S}i$; blue (or violet) and green T., with iron.

(5.) Manganese T. $-\dot{R}\,\ddot{S}i+4\ddot{\dot{R}}\,\ddot{S}i$; red or colourless, with no iron.

Groups 2 and 3 are the most common, and known as *Schorl*, the red varieties as *Rubellite*, the colourless as *Achroite*.

The finest transparent varieties or noble tourmalines come from Ceylon, Siberia, and Brazil. The dark-blue or *Indicollite* occurs chiefly in Utoe. Large crystals of the dark opaque varieties occur in Greenland, Arendal, the Tyrol, and various parts of North America. In England, Bovey in Devonshire and St Just in Cornwall, are well-known localities; and in Scotland, large prisms, often curved or broken, abound in the granite of Aberdeenshire.

Tourmaline is not much valued as a gem, the colours being rarely pure. *Zeuxite* seems only Tourmaline.

*168. CHRYSOLITE, Olivine, Peridot.—$(\dot{M}g,\ \dot{F}e)^2\ \ddot{S}i$. Rhombic; ∞P (*n*) 130° 2′, $\breve{P}\infty$ (*d*) 76° 54′, $2\breve{P}\infty$ (*h*) 80° 53′; also $\infty\breve{P}\infty$ (*M*), $\infty\breve{P}\infty$ with P (*p*), 0P (fig. 152). The crystals are frequently prismatic and imbedded; also massive and granular. Cleavage, $\infty\breve{P}\infty$ rather distinct; fracture conchoidal. H. =6·5...7; G.=3·3...3·5. Transparent or translucent; vitreous. Olive-green, also yellow and brown, rarely colourless. B.B. infusible; soluble and gelatinizing in acids. Chem. com. 38 to 43 silica, 43 to 51 magnesia, 8 to 18 iron protoxide, with a little manganese. *Chrysolite* is the fine green transparent and crystallized varieties from the East, Esne in Egypt, and Brazil. *Olivine*, the darker and less pellucid, from Vesuvius, Unkel

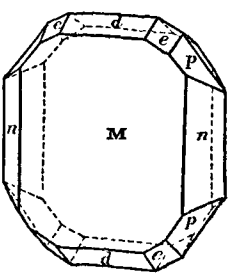


Fig. 152.

on the Rhine, the basalts of Germany, and the trap of Arthur Seat and other parts of Scotland; also in meteoric iron, as in the mass found by Pallas in Siberia, and in that of Otumpa in South America. Used as an ornamental stone, but not much valued.

The following seem mere varieties:—

Hyalosiderite.—Brown or yellow, very ferruginous and metallic-looking; H.=5; G.=2·875; in other respects like olivine; Kaiserstuhl in the Breisgau. *Chusite*, *Limbelite*, and *Tautolite*; Lake Laach. *Batrachite*, greenish-gray or white, translucent; Rizoni Mountain, Tyrol. *Monticellite*, transparent, colourless or yellowish; Vesuvius.

Fayalite.—Crystalline, columnar and foliated, but often as if fused. Greenish or pitch-black, brownish or brass-yellow, with a resinous metallic lustre. H.=6·5; G.=4·15. Partly soluble in h. acid. Chem. com. $\dot{Fe}^2\ddot{S}i$ with 29·7 silica, 70·5 iron protoxide, and 2 to 8 manganese protoxide.

Knebellite.—Massive, opaque, gray, green, brown, or red. Chem. com. 32·5 silica, 32 iron protoxide, and 35 manganese protoxide.

Tephroite.—Granular, with two cleavages at right angles. H.=5·5; G.=4...4·12. Lustre adamantine. Ash-gray, with reddish-brown tarnish. Chem. com. 70 manganese protoxide and 30 silica. Franklin and Sparta, New Jersey.

169. CHONDRODITE, Maclurite, Brucite, Humite. $\left\{ n\dot{M}g^3\ \ddot{S}i^3 + [8\ Mg\ F + 3\ Si\ F^2.] \right.$

Rhombic; $\infty P\ 94°\ 26'$, $\bar{P}\infty\ 112°\ 2'$; but crystals on three types, and often monoclinic in character or indistinct; chiefly in round grains or granular. Cleavage indistinct; fracture imperfect conchoidal. H.=6·5; G.=3·15...3·25. Transparent or translucent; lustre vitreous or resinous. Yellow, red, brown, green, and almost black; streak white or yellowish. B.B. infusible, or only on very thin edges; decomposed by acids. Chem. com. 33 to 37 silica, 55 to 60 magnesia, 2·6 to 9·7 fluorine, with 1·7 to 6·7 iron protoxide. Chondrodite occurs at Pargas in Finnland, Åker, and

Gullsjö in Sweden, Sparta in New Jersey, and Orange county in New York; also in Saxony and on Loch Ness in Scotland. *Humite* on Monte Somma.

Family XIV.—Metallic Stones.

Crystallization predominantly rhombic; some tesseral or monoclinohedric; but many massive, or products of decomposition, and thus rather metallic clays or rocks. The crystalline species are rather hard; H. = 5·5...6·5; and with G. = 3·6...5·6. Those with high specific gravity are mostly infusible B.B., the others fusible. Most are soluble in acids, often gelatinizing. They are chiefly silicates with a metallic base, and thus an intermediate group between the true stones and the metallic ores. Often opaque, and black or brown and yellow. They occur especially in the igneous and metamorphic rocks, or metallic veins of Scandinavia and the Ural.

*170. Lievrite, Yenite, Ilvaite. $\left.\begin{matrix}\\\\\end{matrix}\right\}$ $\ddot{\dot{F}}e^2\,\ddot{S}i + 3\,\dot{F}e^2\,\ddot{S}i + \dot{C}a^3\,\ddot{S}i^2$.

Rhombic; P, polar edges 138° 26′ and 117° 34′, ∞P 111° 12′, $\bar{P}\infty$ 112° 40′. Crystals ∞P2 (*s*) . P(*o*) . $\bar{P}\infty$ (*d*) (fig. 153), are long prismatic and vertically striated; also radiated columnar or fibrous. Cleavages all imperfect; brittle. H. = 5·5...6; G. = 3·9...4·2. Opaque, resinous or imperfect metallic. Brownish or greenish-black; streak black. B.B. fuses easily to a black magnetic globule; soluble in h. acid forming a yellow jelly. Chem. com. 28·8 silica, 24·8 iron peroxide, 33·4 iron protoxide, and 13·0 lime. Rio in Elba, Fossum, Kupferberg, Rhode Island, and Greenland. *Wehrlite*, iron-black, with greenish-gray streak, and B.B. difficultly fusible, is a variety; Hungary.

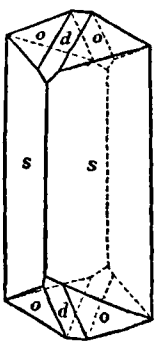


Fig. 153.

171. HISINGERITE, Thraulite.—$\dddot{F}e^2\,\ddot{S}i^3 + 2\,\dot{F}e\,\ddot{S}i + 10\,\dot{H}$.

Reniform, or in crusts. H. = 3·5...4; G. = 2·6...3. Opaque; resinous. Brownish or bluish-black; streak liver or yellowish brown. B.B. fuses with difficulty; soluble in acids, leaving slimy silica. Chem. com. 32·5 silica, 33·5 iron peroxide, 15·1 iron protoxide, and 19 water, of the *Thraulite* from Bodenmais. Also Gillinge, Rydarhyttan in Sweden, and Breitenbrun in Saxony (*Polyhydrite*).

172. ANTHOSIDERITE.—$\dddot{F}e^2\,\ddot{S}i^9 + 2\,\dot{H}$.

Fine fibrous or flower-like; very tough. H. = 6·5; G. = 3. Opaque or translucent; silky. Ochre-yellow to yellowish-brown. B.B. becomes reddish-brown, then black, and fuses with difficulty. Soluble in h. acid. Chem. com. 61 silica, 35 iron peroxide, and 4 water. Minas Geraes in Brazil.

173. NONTRONITE.—$\dddot{F}e\,\ddot{S}i^3 + 5\,\dot{H}$.

Massive. Fracture uneven. G. = 2...2·3; H. = 2...3. Opaque; dull or glimmering; streak resinous. Straw-yellow, yellowish-white, or siskin-green. B.B. decrepitates, becomes black and magnetic, but without fusing; soluble, and gelatinizes in warm acids. Chem. com. nearly 43 silica, 36 iron peroxide, and 21 water, with 3·5 alumina and 2 magnesia. Nontron in France, Harz, and Bavaria.

Chloropal is similar, but B.B. brown and infusible. Unghwar in Hungary, and near Passau. *Pinguite*, sectile; H. = 1; feels greasy; and B.B. fuses on the edges; is also a silicate of iron oxides with water; Wolkenstein in Saxony, near Zwickau, and Suhl.

174. CHLOROPHÆITE.—$(\dot{F}e, \dot{M}g)^3\,\ddot{S}i^4 + 18\,\dot{H}$.

Massive. Cleavage in two directions; fracture conchoidal, earthy; very soft and sectile. G. = 2·02. When first exposed translucent and pistacio or olive-green, but soon changes to brown or black, and opaque. B.B. melts to a black glass. Chem. com. of a specimen from Faroe, 32·85 silica, 22·08 iron protoxide, 3·44 magnesia, and 41·63

water. Scuir More in Rum, Faroe, and Iceland; also in Fife and near Newcastle.

175. THORITE.—$\dot{T}h^3\ \ddot{S}i + 2\ \dot{H}$.

Massive. Fracture conchoidal; hard and brittle. G. = 4·63...4·8. Opaque; splendent, vitreous. Reddish-brown, or black clouded with red; streak dark-brown. B.B. infusible; gelatinizes with h. acid. Chem. com. essentially 73·4 thorina, 16·8 silica, and 9·8 water, but combined with very many other substances: lime, iron, manganese, magnesia, uranium, lead, tin, potash, soda, and alumina. Near Brevig in Norway.

176. EULYTINE.—$\dddot{B}i\ \ddot{S}i^2$.

Tesseral and tetrahedral; $\frac{2O2}{2}$ and $-\frac{2O2}{2}$. The crystals (like fig. 9) very small, and often with curved faces. Cleavage very imperfect; fracture conchoidal. H. = 4·5...5; G. = 5·9...6. Transparent and translucent; adamantine. Clove-brown, yellowish-gray or white; streak white or gray. B.B. fuses readily with intumescence to a brown bead, leaving a yellow ring on the charcoal; decomposed by h. acid, forming gelatinous silica. Chem. com. 21 silica and 79 bismuth peroxide, with 3·3 phosphoric acid, 2·4 iron peroxide, and 1·3 fluorine. Schneeberg, and Bräunsdorf near Freiberg.

Hypochlorite or *Green Iron-earth*, also from Schneeberg, in reniform crusts, or very fine earthy; semitranslucent or opaque. Dull, and siskin or olive-green. H. = 6; G. = 2·9...3. B.B. infusible, but becomes blackish-brown; and forms a yellow ring on the charcoal; insoluble in acids. It seems a mixture of silicate of iron and bismuth with phosphate of alumina.

177. GADOLINITE. $\begin{cases} (\dot{Y}, \dot{C}e, \dot{F}e)^2\ \ddot{S}i, \textit{ and.} \\ (\dot{Y}, \dddot{G}, Fe, \dot{L}a)^3\ \ddot{S}i. \end{cases}$

Monoclinohedric, probably; with P∞ 49°, ∞P 115°, (2 P∞) 70¾° nearly (Scheerer); but crystals rare and indis-

tinct. Cleavage very indistinct, or none; fracture conchoidal or splintery. H. = 6·5; G. = 4·0...4·4. Opaque or translucent on the edges; vitreous, often resinous. Black; streak greenish-gray. B.B. the conchoidal (vitreous) varieties incandesce vividly, intumesce, but do not fuse; the splintery varieties form cauliflower-like ramifications, but do not incandesce; gelatinizes in h. acid. Chem. com. uncertain, but 25 to 29 silica, 36 to 51 yttria, 10 to 15 protoxide of iron, 5 to 17 protoxide of cerium with lanthanium, and 0 to 12 glucina. Krageroe in Norway, Ytterby, and Finbo.

178. ALLANITE, Cerin, Orthite.—3 $\dot{R}^3\,\ddot{S}i^2 + 2\,\ddot{A}l\,\ddot{S}i$.

Monoclinohedric, like epidote, but distinct crystals rare (fig. 154), mostly long, columnar, or granular. Cleavage imperfect; fracture conchoidal or uneven. H. = 6; G. = 3·2...3·7. Opaque, or translucent in thin splinters; imperfect metallic, inclining to vitreous or resinous. Black inclining to green or brown; streak greenish or brownish-gray. B.B. frothes, and melts easily to a black or brown scoria or glass, often magnetic; gelatinizes with h. acid. Chem. com. very variable, but with 30 to 35 silica, 12 to 18 alumina and iron peroxide, whilst $\dot{R}$. includes protoxides of cerium (11 to 24), lanthanium (2 to 8), iron (4 to 21), and manganese (0 to 3·5), with lime (2 to 12), yttria (0·3 to 4), and magnesia (0·4 to 5). *Allanite* occurs in Greenland, also at Hitteroe, the Jotun Fjeld, and Snarum; *Cerin* at Rydderhyttan; *Orthite* at Finbo, Fahlun, Arendal, and Krageroe.

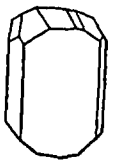


Fig. 154.

Pyrorthite, with carbonaceous and other matter; *Uralorthite*, from the Ilmen Mountains, containing more alumina; *Bodenite*, from Boden, Saxony; and *Bagrationite*, from Achmatofsk, are only varieties.

179. TCHEFFKINITE.

Massive. Fracture flat conchoidal. H. = 5...5·5; G. = 4·5. Opaque; vitreous, splendent. Velvet-black; streak dark-brown. B.B. intumesces greatly, becomes porous,

and often incandesces; in the strongest white heat fuses to black glass; gelatinizes with warm h. acid. Chem. com. 21 silica, 20 titanic acid, 11 iron protoxide, and 47 peroxides of cerium, lanthanium, and didymium. Ilmen Mountains near Miask.

180. CERITE.—$(\dot{C}e, \dot{R})^2 \ddot{S}i + \dot{H}$.

Hexagonal; 0P . ∞P, in low six-sided prisms, but very rare. Generally fine granular, almost compact. Cleavage, traces; fracture uneven, splintery; brittle. H. = 5·5; G. = 4·9...5. Translucent on the edges, or opaque; dull, adamantine, or resinous. Clove-brown, cherry-red, or pearl-gray; streak white. B.B. infusible, but becomes dirty yellow; soluble in h. acid, leaving gelatinous silica. Chem. com. 22 silica, 72 protoxide of cerium (with didymium and lanthanium), and 6 water, with iron protoxide and lime. Bastnaes near Ridderhyttan.

181. TRITOMITE.—$\ddot{S}i, \dot{C}e, \dot{L}a, \dot{C}a, \dot{H}$.

Tesseral in tetrahedrons. Fracture conchoidal; brittle. H. = 5·5; G. = 4·16...4·7. Vitreous; translucent on the edges. Dark-brown. B.B. swells and cracks; soluble in acids. Lamoe near Brevig.

182. PYROCHLORE.—2 $(\dot{C}a, \dot{T}h, \dot{C}e, \dot{F}e)$ $\dddot{N}i + Na\,F$.

Tesseral; O. Cleavage octahedral; brittle; fracture conchoidal. H. = 5; G. = 3·8...4·3. Opaque or translucent; resinous. Dark reddish-brown, or almost black, some crystals ruby-red and transparent; streak pale-brown. B.B. becomes yellow and fuses with much difficulty into a blackish-brown scoria; the fine powder soluble in con. s. acid. Chem. com. very complex, but the Miask variety, 62 to 67 niobic (mixed with titanic and tungstic) acid, 10 to 13 lime, 6 to 13 oxide of cerium and thoria, and 7 fluoride of sodium; but yttria, iron, zirconia, lithia, and in that from Norway, also uranium, occur. Miask in Ural, Brevig and Fredriksvärn in Norway; also Chesterfield in Massachusetts (*Microlite*).

Pyrrhite, small orange-yellow octahedrons; H.=6; is a niobate of zirconia, with iron and uranium. Mursinsk and Azores.

183. OERSTEDTITE.

Tetragonal; P 84° 26′, like zircon. H.=5·5; G.=3·629. Opaque or translucent on the edges; adamantine vitreous. Reddish-brown. B.B. infusible. Forchhammer found 19·71 silica, 2·61 lime, 2·05 magnesia, 1·14 iron protoxide, 68·96 titaniate of zirconia, 5·53 water. Arendal.

184. KEILHAUITE, Yttrotitanite. } $(3\,\dot{C}a\,\ddot{S}i + (\dddot{A}l, \dddot{F}e)\,\ddot{S}i) + \dot{Y}\,\ddot{T}i^3$.

Monoclinohedric; O.=58°, ∞P = 114°. Cleavages, along −2 P intersecting at 138°. H.=6...7; G.=3·5...3·7. Translucent; vitreous or resinous. Blackish-brown; by transmitted light reddish; streak grayish-brown. B.B. fuses easily with effervescence to a black shining slag; with borax forms a blood-red glass in the red. flame; in powder soluble in h.. acid. Chem. com. 28·8 silica, 27·8 titanic acid, 19·5 lime, 9·3 yttria, 6·9 alumina, and 7·7 iron peroxide. Near Arendal.

185. WÖHLERITE.

Rhombic; ∞P 127° 6′, P∞ 140° 54′. Cleavage perfect; fracture conchoidal. H.=5...6; G.=3·41. Translucent; vitreous or resinous. Yellow, inclining to red or brown. B.B. fuses to a yellowish glass; easily soluble in warm con. h. acid, depositing silica and niobic acid. Analysis—30·62 silica, 14·47 niobic acid, 15·17 zirconia, 3·67 iron and manganese protoxide, 26·19 lime, and 7·78 soda. Fredriksvärn (*Eukolite*), and Brevig in Norway.

ORDER II.

SALINE STONES.

Comprises minerals which, in external aspect and composition, resemble (or are) the salts of the chemist. With a few exceptions, as rock-salt and fluor-spar, they are combinations of the second order of two oxygen compounds. The acid component is one of the common acids,—the carbonic, sulphuric, boracic, or phosphoric acid,—not silica or alumina, as in the former order. They are almost all crystallized, and predominantly in rhombic or monoclinohedric forms, but some rhombohedric or tesseral. Their hardness is low; one 7, a few about 5, most lower. G. = 1·5...4·7. All are soluble in acids, except the sulphates (three); more than half in water. B.B. all fusible or decompose. Many of them are products of decomposition. Occur rather in veins than as components of rocks.

**Family I.—Calc-spar.

Generally rhombohedric in crystals and cleavage. H. = 3...4·5; G. = 2·6...3·4, becoming higher as the metallic element increases. They are soluble and often effervesce in acids; and become caustic or alkaline when burned. They form a series of closely-related compounds of carbonic acid with lime, magnesia, and isomorphous bases, as the protoxide of iron. Are generally white, translucent, with a vitreous, or pearly lustre.

**186. Calc-spar, Calcareous Spar, Carbonate of Lime. } $\dot{Ca}\,\ddot{C}$.

Rhombohedral; R 105° 5′; the forms and combinations exceeding those of any other mineral. Among them are

more than thirty rhombohedrons, especially $-\frac{1}{2}$R 135°, R, -2R 79°, and 4R 66°, with 0R and ∞R as limiting forms; more than fifty distinct scalenohedrons, as R^3, R^2, and $\frac{1}{4}R^3$; and the second hexagonal prism $\infty P2$, whilst hexagonal pyramids are among the rarer forms. Some of the most usual combinations are $\infty R . -\frac{1}{2}R$ (fig. 157); or $-\frac{1}{2}R . \infty R$, very frequent; also $\infty R . 0R$; likewise $-2R . R$; $R^3 . \infty R . -2R$; $R^5 (y) . R^3 (r) . R (P) . 4R (m) . \infty R (C)$ (fig. 155); and many others, upwards of an hundred distinct combinations being known.

Macles are not uncommon, especially with the systems of axes parallel (figs. 156, 157), and others conjoined by a

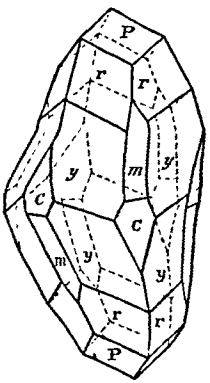


Fig. 155.

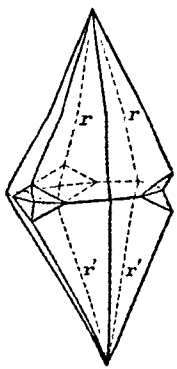


Fig. 156.

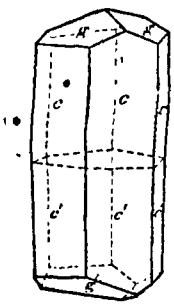


Fig. 157.

face of R with the chief axes almost at right angles, 89° 8′ (fig. 82); or by a face of $-\frac{1}{2}$R, in which the chief axes form an angle of 127½°; and usually many times repeated, so that the centre crystals appear in lamellæ not thicker than paper (fig. 81). Cleavage, rhombohedric along R very perfect and easily obtained, so that the conchoidal fracture is rarely observable; brittle. H.=3; G.=2·6...2·8; pure transparent crystals=2·72. Pellucid in all degrees. Very distinct double refraction. Lustre vitreous, but several faces resinous, and 0R pearly. Most frequently colourless or white,

but often gray, blue, green, yellow, red, brown, or black; streak grayish-white. B.B. infusible, but becomes caustic and emits a bright light; effervesces, and is entirely soluble in h. or n. acid. The fine powder ignited on platina-foil over the spirit-lamp, according to *v. Zehmen*, forms a somewhat connected mass, and even adheres to the platina. Chem. com. of the purest varieties, carbonate of lime, with 43·87 carbonic acid and 56·13 lime, or 40 calcium, 12·2 carbon, and 47·8 oxygen; but usually contain magnesia and protoxide of iron or manganese. Remarkable specimens of the crystallized variety, or proper calc-spar, are found in Andreasberg and other parts of the Harz (six-sided prisms), Freiberg, Tharand, Maxen, Alston Moor in Cumberland (flat rhombic crystals), and in Derbyshire (pale yellow transparent pyramids).

Certain varieties are distinguished, as,—Iceland spar, remarkable for its transparency and double refraction, occurs massive in a trap rock in that island. *Slate spar*, thin lamellar, often with a shining white pearly lustre, and greasy feel; Wicklow in Ireland, Glentilt in Scotland, and Norway. *Aphrite*, fine scaly, from Hessia and Thuringia. *Marble* is the massive crystalline variety of this mineral, produced by igneous action on compact limestone. Paros, Naxos, and Tenedos furnished the chief supply to the Grecian artists; Carrara, near the Gulf of Genoa, to those of modern times. Some of the coloured marbles of the ancients were impure limestones, as the *Cipollino*, zoned with green talc or chlorite; and *Verde antique*, mixed with green serpentine. *Ruin marble* shows irregular markings like ruins; Val d'Arno (Florentine marble), and Bristol (Cotham marble). *Lucullite*, from Egypt, and *Anthraconite*, from Kilkenny in Ireland, are black from carbon. *Lumachello*, from Bleiberg in Carinthia, exhibits beautiful iridescent colours from fossil shells, sometimes deep-red or orange (*Fire marble*).

Limestone occurs in all formations under various names,

as *Oolite*, egg or roe-stone, round concretions, with a concentric structure like the roe of fish; *Pisolite*, or peastone, similar structure; *Chalk*, soft earthy; *Lithographic stone*, yellowish and compact, from Solenhofen; and *Marl*, calcareous matter more or less mixed with clay. *Tufa*, or calcareous tufa, generally a recent deposit from calcareous springs, has often a loose friable texture, but at other times is hard and compact; and in the neighbourhood of Rome forms the common building-stone or *Travertino*. The sandstone of Fontainbleau is carbonate of lime ($\frac{1}{3}$) mixed with quartz sand ($\frac{2}{3}$), and occasionally crystallizing in rhombohedrons.

This mineral is employed in many ways,—the coarser varieties, as lime, for mortar, manure, tanning, a flux in melting iron and other ores, or in preparing glass, and similar purposes; the finer, as marbles, for sculpture, architecture, and ornamental stone-work; the chalk for writing, white-washing, or producing carbonic acid.

Plumbocalcite.—Cleavage, R 104° 53′. White and pearly; softer than calc-spar; but G.=2·824. Contains 2·3 to 7·8 carbonate of lead. Wanlockhead and Leadhills, Scotland.

**187. DOLOMITE, Bitter Spar.—$\dot{C}a\ \ddot{C} + \dot{M}g\ \ddot{C}$.

Rhombohedric; R 106° 15′—20′; most frequent form R; also R and $-\frac{1}{2}$R, or 0R, ∞R, and 4R. The rhombohedrons often curved and saddle-shaped; also granular or compact, often cellular and porous. Cleavage, rhombohedral along R. H.=3·5...4·5; G.=2·85...2·95. Translucent; vitreous, but often pearly or resinous. Colourless or white, but frequently pale-red, yellow, or green. B.B. infusible, but becomes caustic, and often shows traces of iron and manganese; fragments effervesce very slightly or not at all in hydrochloric acid; the powder is partially soluble, or wholly when heated; the very fine powder ignited on platina-foil for a few minutes over a spirit-lamp *continues* pulverulent, but intumesces slightly during ignition. Chem. com. generally carbonate of lime, with more than 20 per

cent. carbonate of magnesia and less than 20 per cent. carbonate of iron.

Varieties are,—*Dolomite*, massive, granular, easily divisible, white; *Rhomb* or *Bitter-spar*, larger grained, or distinctly crystallized and cleavable, often inclining to green; and *Brown-spar* and *Pearl-spar*, in simple crystals or in imitative forms, of colours inclining to red or brown, more distinct pearly lustre, and under 10 per cent. carbonate of iron. Traversella in Piedmont, St Gotthardt, Gap in France, Alston in Cumberland, in Derbyshire, and at Leadhills and Charlestown in Scotland. Greenish, macled; Miemo, in Tuscany (*Miemite*), and Tharand in Saxony (*Tharandite*). *Gurhofian*, from Gurhof in Austria, is white and compact.

The massive and compact varieties are very common, and valued as building-stones (cathedral of Milan, York Minster, and the New Houses of Parliament). The Parian marble, and also the Iona marble in the Hebrides, have been supposed to belong to this species.

Predazzite.—Granular; white and vitreous on the cleavage planes. H.=3·5; G.=2·623. Contains 6·98 per cent. water. Predazzo in Tyrol.

188. BREUNNERITE, Giobertite.—$\dot{M}g\ \ddot{C}$.

Rhombohedral; R 107° 10′—30′; as yet only R; and granular or columnar. Cleavage, R very perfect, with straight faces. H.=4...4·5; G.=2·9...3·1. Transparent or translucent on the edges; highly vitreous. Colourless, but often yellowish, brown, or blackish-gray. B.B. infusible, but generally becoming gray, or black and magnetic; soluble in acids, often only when pulverized and warmed. Chem. com. essentially carbonate of magnesia, with 51·7 carbonic acid and 48·3 magnesia, but often mixed with 8 to 17 carbonate of iron or manganese. Tyrol, St Gotthardt, Harz, Fassathal; also Unst in Zetland.

Mesitine-spar, splendent, yellow, lenticular crystals; G. =3·35...3·4; Traversella in Piedmont: and *Pistomasite*; G.=4·4; Salzburg; are similar.

189. MAGNESITE.—$\dot{M}g.\ddot{C}$.

Reniform or massive. H.=3...5; G.=2·85...2·95. Sub-translucent or opaque; streak shining. Snow-white, grayish, or yellowish-white, and pale-yellow. Adheres slightly to the tongue. B.B. and with acids acts like breunnerite. Chem. com. pure carbonate of magnesia, with no metallic oxides. Tyrol, Norway, North America.

190. HYDROMAGNESITE.—$\dot{M}g^4\ \ddot{C}^3+4\ \dot{H}$.

Monoclinohedric; C=82½°, ∞P 88° nearly. Crystals small, acicular; also massive. H.=1·5...3·5; G.=2·14... 2·18. Vitreous or silky. White. B.B. infusible; soluble with effervescence in acids. Chem. com. 36·2 carbonic acid, 44 magnesia, and 19·3 water. Moravia, Kumi, Hoboken in New Jersey, and Texas in Pennsylvania. The *Hydromagnocalcite* is a similar yellow sinter from Vesuvius with part of the magnesia replaced by lime.

**191. ARRAGONITE, Needle Spar, Flos-ferri.—$\dot{C}a\ \ddot{C}$.

Rhombic; ∞P 116° 16′, $\breve{P}\infty$ 108° 27′. The most common combinations are $\infty\breve{P}\infty$ (*h*), ∞P (*M*) . $\breve{P}\infty$ (*h*, *P*), generally long prismatic (like fig. 158, and separate crystals in fig. 159); ∞P∞ . ∞P . 0$\breve{P}$, generally short prismatic; 6$\breve{P}\frac{3}{4}$. ∞P . $\breve{P}\infty$, acute pyramidal. But simple crystals are rare,

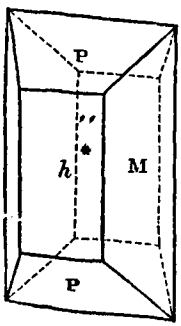


Fig. 158.

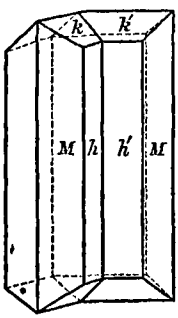


Fig. 159.

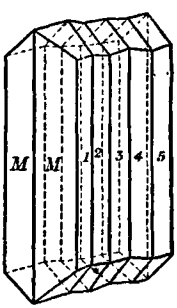


Fig. 160.

from the great tendency to form macles, conjoined by a face of ∞P, and repeated (figs. 159, 160). Also columnar,

fibrous, and in crusts, stalactites, and other forms. Cleavage, brachydiagonal distinct, also ∞P and P̆∞ imperfect; fracture conchoidal or uneven. H.=3·5...4; G.=2·8 ...3 (massive 2·7). Transparent or translucent; vitreous. Colourless, but yellowish-white to wine-yellow, reddish-white to brick-red; also light-green, violet-blue, or gray. In the closed tube, before reaching a red heat, it swells and falls down into a white coarse powder, evolving a little water. A portion of this powder heated in the forceps, B. B., colours the flame carmine-red when strontia is present; on charcoal it becomes caustic, and with fluxes acts like calc-spar. Chem. com. carbonate of lime, occasionally mixed with (0·1...4) carbonate of strontia. Valencia, Molina, and in Arragon; Leogang in Salzburg, and Antiparos. *Flos-ferri*, coralloid, in the iron mines of Styria. *Satin-spar*, fine fibrous silky, at Dufton; stalactitic in Buckinghamshire, Devonshire, coast of Galloway, and Leadhills; also deposited as tufa by the Carlsbad and other hot springs.

Arragonite is most readily distinguished from calc-spar by falling to pieces at a low temperature, and by its less distinct and prismatic cleavage.

Tarnowitzite contains 2 to 4 carbonate of lead. Tarnowitz in Silesia.

**Family II.—Fluor Spar.

Crystallization tesseral, hexagonal, or rhombic. H.=4 ...5, in one 7; G.=2·9...4·7, but mostly about 3. All soluble in acids, and mostly fusible or altered by heat. Those containing fluorine, when warmed with concentrated sulphuric acid, evolve vapours that corrode glass; those with phosphoric acid, when moistened with sulphuric acid, colour B.B. the flame green.

**192. Fluor Spar.—Ca F.

Tesseral; the most common form is the cube ∞O∞, then the octahedron O, and the rhombic dodecahedron ∞O;

but many other forms occur in combinations. Macles are common; also coarse granular, columnar, or compact and earthy. Cleavage, octahedral perfect; conchoidal fracture; brittle. H.=4; G.=3·1...3·2. Pellucid in all degrees; vitreous. Colourless, but generally very various, and beautiful shades of yellow, green, blue, and red; often two or more in one specimen. Many varieties phosphoresce when heated (*Chlorophane*, with a bright green light). B.B. decrepitates, often violently, phosphoresces and fuses in thin splinters to an opaque mass; slowly soluble in h. or nitric acids, readily in s. acid, with evolution of hydrofluoric acid. Chem. com. neutral fluoride of calcium, containing 48·14 fluorine, and 51·86 calcium (=72·45 lime), Fluor-spar is a very common mineral, chiefly in veins, as with tin ores in Saxony, Bohemia, Cornwall; with silver at Freiberg, Marienberg, Kongsberg; with lead in Derbyshire (near Castletown), Cumberland (Alston Moor), Northumberland and Ireland. It is rare in Scotland, but in greenstone near Gourock, in granite near Ballater in Aberdeenshire, on the Avon in Banffshire, and in Sutherland. In Derbyshire it occurs in large crystalline masses either with concentric colours or of a rich translucent blue (*Blue John*), and is wrought into various ornamental articles. Fluor spar is also used for etching on glass, and as a flux in reducing metallic ores, especially iron and copper.

193. YTTROCERITE.

Very similar to fluor spar. Granular, crystalline, or in crusts. Cleavage imperfect. H.=4...5; G.=3·4...3·5. Translucent or opaque; weak vitreous lustre. Violet-blue to gray or white. B.B. infusible on charcoal alone, and evolves fluorine when heated with s. acid. Chem. com. fluorides of calcium, cerium, and yttrium, in variable proportions. Finbo and Broddbo near Fahlun, Massachusetts, and Amity in New York.

194. FLUOCERITE.— $Ce\,F + Ce^2\,F^3$.

Hexagonal; $\infty P\,.\,0P$. H.=4...5; G.=4·7. Opaque or

translucent on the edges; lustre weak. Pale brick-red or yellowish; streak yellowish-white. In the closed tube gives out fluorine. B.B. infusible. Chem. com. 82·64 peroxide of cerium, 1·12 yttria, and 16·24 hydrofluoric acid, *Berzelius*. Finbo and Broddbo.

195. FLUOCERINE.—$Ce^2 F^3 + \ddot{C}e \dot{H}$.

Massive, with traces of cleavage; fracture conchoidal. H. = 4·5. Opaque; vitreous or resinous. Yellow, inclining to red or brown; streak brownish-yellow. B.B. infusible. Analysis, 84·21 peroxide of cerium, 10·85 hydrofluoric acid, and 4·95 water. Finbo. A similar mineral from Bastnaes gave fluoride of cerium (and lanthanium) 50·15, peroxide of cerium 36·43, and water 13·4.

196. CRYOLITE.—3 Na F + $Al^2 F^3$.

Rhombic (or tetragonal ?), but only indistinct crystalline or, granular. Cleavage, basal perfect, two others less so, the three nearly at right angles; brittle. H. = 2·5...3; G. = 2·9...3. Translucent, and after immersion in water almost transparent; vitreous, but on 0P rather pearly. Colourless and snow-white, but often grayish, yellowish, or reddish. B.B. fuses very easily (even in the flame of a candle) to a white enamel; in open tube shows traces of fluorine; partially soluble in h. acid; wholly so in s., with evolution of fluorine. Chem. com. 53·7 fluorine, 13·1 aluminium, and 33·2 sodium. Arksutfiord in West Greenland, Miask in Ural. Used as an ore of aluminium.

197. CHIOLITE.— $\begin{cases} 3 \text{ Na F} + 2 \text{ Al}^2 \text{F}^3 = \text{A} \\ 2 \text{ Na F} + \text{Al}^2 \text{F}^3 = \text{B}. \end{cases}$

Tetragonal, with middle edge 113° 25′ (or rhombic with ∞P 124° 22′); mostly granular. Cleavage, P rather perfect. H. = 4. Resinous. White. Very easily fusible (more so than cryolite), colouring the flame deep yellow; evolves fluoric acid. Chem. com. twofold; one variety (A) with G. = 2·8...2·9, containing 18·7 aluminium, 23·8 sodium, and 57·5 fluorine; the second (B), with G. = 3·0...3·1, containing

16·4 aluminium, 27·8 sodium, and 55·8 fluorine. Miask in Siberia.

Fluellite.—Small, white, transparent, rhombic pyramids; polar edges 109° 6′ and 82° 12′, middle 144°. Consists essentially of fluorine and aluminium. Stenna-gwyn in Cornwall.

Prosopite.—Crystals like datholite. H. = 4·5. Vitreous. Colourless and transparent. Contains fluorine, aluminium, calcium, and water. Altenberg; Schlackenwalde (?).

198. HOPEITE.

Rhombic; $\infty\breve{P}2$, 82° 20′; P with polar edges 106° 36′ and 140°. Cleavage, macrodiagonal perfect. H. = 2·5...3; G. = 2·76...2·85. Vitreous or pearly. Grayish-white. B.B. melts to a clear globule, tinging the flame green; soluble in acids without effervescence. Chem. com. oxide of zinc and cadmium, with phosphoric (or boracic ?) acid, and much water. Altenberg near Aix la Chapelle.

**199. APATITE.—$3\,\dot{C}a^3\,\ddot{\dot{P}} + Ca\,(Cl, F)$.

Hexagonal, and pyramidal-hemihedric; P 80° 26′; the

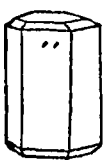


Fig. 161.

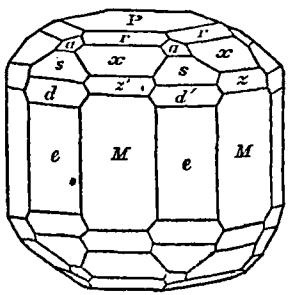


Fig. 162.

most common forms are ∞P (*M*), $\infty P2$ (*e*), $0P$ (*P*), P (*x*). The crystals (figs. 161, 162) are short prismatic or thick tabular, and often striated vertically. Also granular, fibrous, or compact. Cleavage, prismatic and basal both imperfect; fracture conchoidal or uneven and splintery; brittle.

H. = 5; G. = 3·16...3·25. Transparent to opaque; vitreous, but resinous on the cleavage planes and fracture. Colourless, and white, but generally light-green, gray, blue, violet, or red. B.B. fusible in thin splinters with much difficulty to a colourless, translucent glass; moistened with sulphuric acid it colours the flame green; soluble in nitric or h. acid. Chem. com. phosphate of lime (91 to 92·3), with chloride (0 to 4·2) and fluoride (4·6 to 7·7) of calcium. In tin mines in Saxony, Bohemia, St Michael's Mount, St Agnes, and Botallack in Cornwall; in granite at Bovey Tracey in Devonshire, and at Calbeck Fell in Cumberland; also at St Gotthardt, the Tyrol, and at Hammond and Edenville in New York. *Moroxite*, opaque greenish-blue from Arendal. *Asparagus-stone*, translucent, wine-yellow crystals, from the Zillerthal in Tyrol. *Phosphorite*, massive, from Logrosan in Estremadura.

Magnesia-apatite, from Kusiusk in the Ural, contains 7·74 magnesia.

200. HERDERITE, Allogonite.—$\dddot{\mathrm{Al}}$, $\dot{\mathrm{Ca}}$, $\dddot{\mathrm{P}}$, F.

Rhombic; P middle edge 77° 20′, ∞P 115° 53′. Cleavage, 0P and ∞P imperfect; fracture conchoidal. H. = 5; G. = 2·9...3. Translucent; vitreous, inclining to resinous. Yellowish or greenish-white. B.B. difficultly fusible to a white enamel; moistened with s. acid colours the flame green; soluble in warm h. acid. Ehrenfriedersdorf in Saxony, but extremely rare.

201. CHILDRENITE.—$2(\dot{\mathrm{Fe}}, \dot{\mathrm{Mn}})^4\ \dddot{\mathrm{P}} + \dddot{\mathrm{Al}}^3\ \dddot{\mathrm{P}} + 15\ \dot{\mathrm{H}}$.

Rhombic; P 102° 41′, 130° 4′, 97° 52′; usual form P. $2\breve{\mathrm{P}}\infty$. $\infty\breve{\mathrm{P}}\infty$ (fig. 163). Cleavage, P imperfect. H = 4·5...5. G. = 3·18...3·3. Translucent; vitreous. Yellowish-white to wine or ochre-yellow, brown, or almost black. B.B. infusible, but colours the flame bluish-green; slowly soluble in warm h. acid. Chem. com. 30·7 iron protoxide, 9 manganese protox., 14·5 alumina, 29

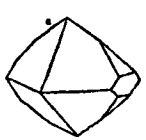


Fig. 163.

phosphoric acid, and 17 water. Tavistock in Devonshire, Crinnis in Cornwall, and Callington in Cumberland.

202. XENOTIME.—$\dot{Y}^3 \dddot{P}$.

Tetragonal; P 82° 30′. Crystals P . ∞P. Cleavage, ∞P. H. = 4·5; G. = 4·39...4·55. Translucent in thin splinters; resinous. Yellowish or reddish-brown, and flesh-red; streak paler. B.B. infusible. Chem. com. 62·82 yttria, and 37·18 phosphoric acid, with traces of fluoric acid, and 3·39 phosphate of iron. Lindesnaes and Hitteroe in Norway, Ytterby and Georgia, U.S.

203. BORACITE.—$\dot{Mg}^3, \dddot{B}^4$.

Tesseral, and hemihedric; ∞O∞, ∞O, and $\frac{O}{2}$. Cleavage, octahedral very imperfect; fracture conchoidal; brittle. H. = 7; G. = 2·9...3. Transparent, or translucent on the edges. Vitreous or adamantine. Colourless or white, often grayish, yellowish, or greenish. Becomes polar electric by heat. B.B. fuses with difficulty to a clear yellowish bead, which on cooling forms a white opaque mass of needle-like crystals; at same time colours the flame green; soluble in h. acid. Chem. com. 69·8 boracic acid, and 30·2 magnesia. Lüneberg and Segeberg in Holstein.

Stassfurthite.—Compact, or in very minute prismatic crystals. White. Chem. com. same as boracite, and thus dimorphous. Stassfurth in Germany.

Rhodizite agrees with boracite; only H. = 8 and G. = 3·3...3·42. B.B. fuses difficultly on the edges, colouring the flame first green, then green above and red below, and at last in some varieties all red. Chem. com. borate of lime. Mursinsk in Siberia.

204. HYDROBOROCALCITE.—$\dot{Ca}\,\dddot{B}^2 + 6\,\dot{H}$

Delicate snow-white crystals, with 19 lime, 46 boracic acid, and 35 water. Iquique in Peru.

205. HYDROBORACITE.—$\dot{Ca}^2\,\dddot{B}^3 + \dot{Mg}^2\,\dddot{B}^3 + 12\,\dot{H}$.

Radiating and foliated like gypsum. H. = 2; G. = 1·9...2. Translucent. White, but partly red. B.B. melts

easily, tinging the flame green; easily soluble in warm acids. Chem. com. 13·52 lime, 10·57 magnesia, 49·58 boracic acid, and 26·33 water. Caucasus. A similar mineral with soda in place of magnesia is found in Peru.

*206. DATHOLITE, Borate of Lime.—$\dot{Ca}\,\ddot{B} + \dot{Ca}\,\ddot{Si} + \dot{H}$.

Monoclinohedric; C=88° 19′, ∞P (*f*) 77° 30′, ∞P2 (*g*) 116° 9′, −P (*P*) 122°, −2P∞ (*a*) 43° 56′, (∞P∞) (*s*), 2P∞) (*o*) (fig. 164); or rhombic with *b*:*f* 90°, *b*:*a* 135°; *b*:*c* 141° 9′, and *f*:*g* 160° 39′; also coarse granular. Cleavage, orthodiagonal and ∞P very imperfect; fracture uneven or conchoidal. H.=5...5·5; G.=2·9...3. Transparent or translucent; vitreous; on the fracture resinous. Colourless or white, inclining to gray, green, yellow, and red. In closed tube yields water. B.B. intumesces, and melts easily to a clear glass, colouring the flame green; the powder gelatinizes in h. acid. Chem. com. 38·3 silica, 21·5 boracic acid, 34·6 lime, and 5·6 water. Arendal, Utoe, Andreasberg, Seisser Alpe, Sonthofen (*Humboldtite*); Toggianna in Modena; also Salisbury Crags, Corstorphine Hill, and Glen Farg, in Perthshire; Connecticut and New Jersey.

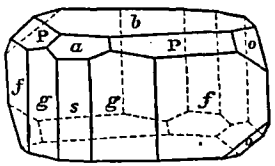


Fig. 164.

Botryolite.—Fine fibrous, botryoidal or reniform, snow-white or hair-brown; otherwise, and in chem. com., like datholite, but with two atoms water. Arendal.

FAMILY III.—HEAVY SPAR.

Crystallization rhombic specially. H.=3...4·5; G.=3·2...4·7, but mostly 3·6...4·5. Soluble in acids, except barytes. B.B. fusible or decomposé. Those containing baryta colour the flame yellowish-green; those with strontia carmine red, best seen when moistened with h. acid. The sulphates fused with soda and then moistened leave a black stain on silver.

**207. BARYTES, Heavy Spar.—$\dot{B}a\,\ddot{S}$.

Rhombic; ∞P (*g*) 101° 40′, $\breve{P}\infty$ (*f*) 74° 35′, $\frac{1}{2}\bar{P}\infty$ (*d*) 102° 17′; and 0P (*c*), (figs. 165, 166, 167). The crystals tabular or columnar, often in druses or groups; also foliated, fibrous, granular, or compact. Cleavage, basal perfect, prismatic along ∞P less perfect; brachydiagonal traces. H. = 3...3·5; G. = 4·3...4·7(4·48). Transparent to translucent; vitreous or resinous. Colourless and white, but generally reddish-white, or flesh-red, yellow, gray, bluish, greenish, or brown.. B.B. decrepitates violently, and fuses very difficultly, or only on the edges, colouring the flame yellowish-green; not soluble in acids. Chem. com. 34·3 sulphuric acid, and 65·7 baryta, but occasionally with 1 to 15 sulphate of strontia. Very common, chiefly in veins, either alone or accompanying ores. Crystals at Dufton, Bohemia, Felsobanya and Kremnitz in Hungary, Auvergne, and United States. Columnar at Freiberg. The radiated from near Bologna, or the *Bolognese stone*, phosphoresces in the dark. Massive or *Cawk* from Derbyshire and Staffordshire; in Scotland at Leadhills, Braid Hills near Edinburgh, the Pentlands and Cheviots, and Arran, where mined as a white pigment.

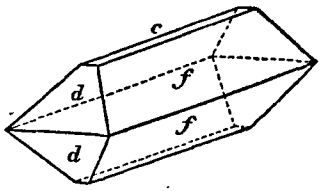


Fig. 165.



Fig. 166.

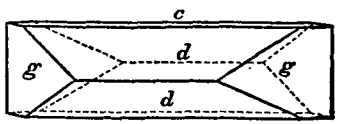


Fig. 167.

Lime Barytes, from Freiberg, Strontian, and Derbyshire, seems a mixture with sulphate of lime; crystals, tabular, in rosettes and other groups. G. = 4·0...4·3.

Hepatite.—Dark-gray, from carbonaceous matter; Kongs-

berg. *Allomorphite*, scaly, white and pearly, at Unterwirbach near Rudolstadt, agrees essentially (98·05 sulphate of baryta, 1·90 sulphate of lime) with barytes.

208. DREELITE.—$\dddot{Ca}\,\dddot{S} + 3\,\dot{Ba}\,\dddot{S}$.

Rhombohedric; R 93°. Cleavage, R imperfect. H.= 3...4; G.=3·2···3·4. Lustre dull; on cleavage pearly. White. B.B. fuses to a white vesicular glass; effervesces with h. acid, but only partially dissolves. Chem. com. 61·73 sulphate of baryta, 14·27 sulphate of lime, 8·05 carbonate of lime, 9·71 silica, 2·40 alumina, 1·52 lime, 2·31 water. Nuissière near Beaujeu.

*209. WITHERITE.—$\dot{Ba}\,\ddot{C}$.

Rhombic; ∞P 118° 30′, $2\breve{P}\infty$ 68°. Crystals $\infty P \cdot P\infty \cdot 2\breve{P}\infty$ (fig. 168); more common spherical, botryoidal, or reniform, with radiated columnar texture. Cleavage, ∞P distinct, $2P\infty$ and $\infty\breve{P}$ imperfect; fracture uneven. H.=3...3·5; G. =4·2...4·3. Semitransparent or translucent; vitreous, or resinous on the fracture. Colourless, but generally yellowish or grayish. B.B. fuses easily to a transparent globule, opaque when cold; on charcoal boils, becomes caustic and sinks into the support; soluble with effervescence in nitric or h. acid. Chem. com. 22·3 carbonic acid and 77·7 baryta. Alston Moor in Northumberland, and Lancashire, where it is used for poisoning rats; also in Styria, Salzburg, Hungary, Sicily, Siberia, and Chili.

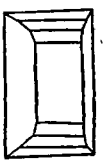


Fig. 168.

210. ALSTONITE.—$\dot{Ba}\,\ddot{C} + \dot{Ca}\,\ddot{C}$.

Rhombic; ∞P 118° 50′, $2\breve{P}\infty$ 111° 50′; usual combination $P \cdot 2\breve{P}\infty \cdot \infty P$, resembling a hexagonal pyramid. Cleavage, ∞P and $\infty\breve{P}\infty$ rather distinct. H.= 4...4·5; G.=3·65...3·76. Translucent; weak resinous. Colourless or grayish-white. Chem. com. 66 carbonate of baryta and 34 carbonate of lime, thus identical with the baryto-calcite. Fallowfield near Hexham, and Alston Moor.

211. BARYTO-CALCITE.—$\dot{B}a\,\ddot{C} + \dot{C}a\,\ddot{C}$.

Monoclinohedric; C.=69° 30′; ∞P 95° 15′, P 106° 54′, P∞ 119° (fig 169); also columnar and granular. Cleavage, P perfect, P∞ less perfect. H.=4; G.=3·6...3·7. Transparent or translucent; vitreous, inclining to resinous. Yellowish-white. B.B. infusible, but becomes opaque and caustic. Chem. com. like Alstonite, Alston Moor.

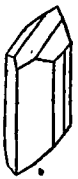


Fig. 169.

*212. CELESTINE.—$\dot{S}r\,\dddot{S}$.

Rhombic; forms like those of barytes and sulphate of lead; ∞P 104° 8′, P∞ 75° 58′. Usual combinations $\breve{P}\infty$. ∞P . 0P, this with $\frac{1}{2}$P∞, also 0P . ∞P (fig. 170); also columnar, and foliated; or fibrous, fine granular or compact. Cleavage, basal perfect; prismatic along ∞P less perfect. H.=3...3·5; G.=3·9...4. Transparent or translucent; vitreous or resinous. Colourless, but usually bluish-white to indigo-blue, and rarely reddish or yellowish.

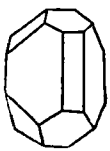


Fig. 170.

B.B. decrepitates and fuses easily to a milk-white globule; colours the flame carmine-red. Distinguished from barytes by a splinter after ignition in the inner flame, being moistened with h. acid, and held in the blue border of the flame of a candle, colouring this of a lively purple-red. Scarcely affected by acids. Chem. com. 43·6 sulphuric acid, and 56·4 strontia. Sulphur mines of Girgenti and other parts of Sicily, Herrengrund in Hungary, Bex, Salzburg, Monte Viale near Verona, and Meudon and Montmartre near Paris; in England near Bristol, and Knaresborough; in Scotland at Inverness, Tantallan Castle, Calton Hill. Used for strontium preparations, and red-light in fire-works.

Baryto-celestine.—Radiating columnar or foliated. Bluish-white; very brittle and friable. H.=2·5; G.=3·92. B.B. difficultly fusible. Chem. com. $2\,\dot{S}r\,\dddot{S} + \dot{B}a\,\dddot{S}$, with 36 strontia, and 23 baryta. Diamond Island in Lake Erie, Kingstown in Upper Canada, and Binnenthal.

*213. STRONTIANITE.—$\dot{S}r\ \ddot{C}$.

Rhombic; ∞P 117° 19′, $\breve{P}\infty$ 108° 12′. Crystals (fig. 171) and macles like arragonite; also broad columnar and fibrous. Cleavage, prismatic along ∞P (*M*), and 2 $\breve{P}\infty$ (*P*) (69° 16′) imperfect. H.=3·5; G.=3·6 ...3·8. Translucent or transparent; vitreous or resinous on fracture. Colourless, but often light asparagus or apple-green, more rarely grayish or yellowish. B.B. fuses in a strong heat only on very thin edges; intumesces in cauliflower-like forms, shines brightly, and colours the flame red; easily soluble with effervescence in acids; the solution in hydrochloric acid, evaporated and then dissolved in alcohol, makes this burn with a carmine-red flame. Chem. com. 30 carbonic acid and 70 strontia, but often contains carbonate of lime (6 to 8). Leogang in Salzburg, Bräunsdorf in Saxony, Hamm in Westphalia, the Harz; at Schoharie and other parts of the United States (*Emmonite*); Strontian in Argyllshire, Leadhills, Yorkshire, and Giant's Causeway. It is used to produce red fire in pyrotechnic exhibitions.

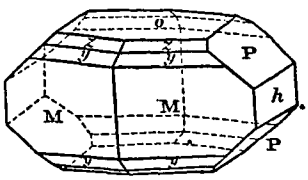


Fig. 171.

Stromnite or *Barystrontianite.*—Yellowish-white, semi-translucent, faint pearly lustre. H.=3·5; G.=3·7. Contains 68·6 carbonate of strontia, 27·5 sulphate of baryta, and 2·6 carbonate of lime. Stromness in Orkney.

FAMILY IV.—GYPSUM.

Crystallization rhombic or monoclinohedric. H.=2...3, or less, many yield to the nail. G.=2·2...2·9, or also low. All, except the sulphates, soluble in acids, some in water; also fusible in general. Mostly translucent and colourless, but often coloured by mixtures.

**214. GYPSUM.—$\dot{C}a\ \dddot{S} + 2\ \dot{H}$.

Monoclinohedric; C.=81° 26′; the most common forms

are ∞P 111° 14′, P 138° 44′, −P 143° 28′, and (∞P∞). Two common combinations are ∞P (*f*) . (∞P∞) (*P*) . —P (*l*) (fig. 172), and this with P. Lenticular crystals often occur; macles frequent (fig. 83 above); also granular, compact, fibrous, scaly, or pulverulent. Cleavage, clinodiagonal very perfect, hemipyramidal along P much less perfect; sectile, thin plates flexible. H.= 1·5 ... 2 (lowest on *P*); G.=2·2 ... 2·4. Transparent or translucent; vitreous, on cleavage pearly or silky. Colourless and snow-white, but often red, gray, yellow, brown, and more rarely greenish or bluish. In the closed tube yields water. B.B. becomes opaque and white; exfoliates and fuses to a white enamel, which is alkaline; soluble in 400 to 500 parts of water, scarcely more so in acids. Chem. com. sulphate of lime with two atoms water, or 46·47 sulphuric acid, 32·65 lime, and 20·88 water.

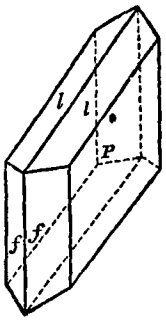


Fig. 172.

Gypsum is a very common mineral, often in nests or reniform masses in clay or marl. Transparent crystals, or *Selenite*, occur in the salt mines of Bex in Switzerland, of the Tyrol, Salzburg, and Bohemia, in the sulphur mines of Sicily, at Lockport in New York, in the clay of Shotover Hill near Oxford, at Chatley near Bath, and many other localities. Fibrous gypsum at Ilfeld in the Harz, and Matlock in Derbyshire. Compact gypsum at Volterra in Tuscany (*Alabaster*), and in whole beds in many parts of Germany, France, Italy, and England, often with rock-salt.

The finer varieties, or *Alabaster*, are cut into various ornamental articles. Plaster of Paris, used for casts and other works of art, is formed by calcining gypsum at a temperature below 300° Fahr., and grinding it down to a fine powder, which forms a paste that soon hardens by absorbing the water driven off by the heat.

*215. ANHYDRITE, Muriazit, Karstenite.—$\dot{Ca}\,\dddot{S}$.

Rhombic; ∞P 91° 10′, $\breve{P}\infty$ 96° 36′. Crystals $0P\,.\,\infty\bar{P}\infty\,.\,\infty\breve{P}\infty\,.\,\infty P$, but rare; chiefly granular, or almost compact or columnar. Macles rare. Cleavage, macrodiagonal and brachydiagonal both very perfect, basal perfect. H.=3 ...3·5; G.=2·8...3. Transparent or translucent; vitreous; on $\infty\breve{P}\infty$ pearly. Colourless or white, but often blue, red, or gray; streak grayish-white. In closed tube gives no water. B.B. fuses difficultly to a white enamel; with fluor spar fuses readily to a clear globule, which becomes opaque when cold, and, on continuation of the heat, intumesces and becomes infusible; very slightly soluble in water or acids. Chem. com. 58·75 sulphuric acid and 41·25 lime.

The crystalline, or *Muriacite*, occurs in the salt mines of Bex, Hall in Tyrol, and Aussee in Styria; also Sulz on the Neckar, and Bleiberg. Compact at Ischel in Austria, Berchtesgaden, Eisleben, and the Harz. Granular, or *Vulpinite*, near Bergamo. The contorted, or *Gekrösstein*, chiefly at Wieliczka and Bochnia.

216. POLYHALITE.—$2\,\dot{Ca}\,\dddot{S} + \dot{Mg}\,\dddot{S} + \dot{K}\,\dddot{S} + 2\dot{H}$.

Rhombic; ∞P 115°; mostly columnar or fibrous. Cleavage, ∞P imperfect. H.=3·5; G.=2·7...2·8. Translucent; pearly or resinous. Colourless, but generally pale red, seldom gray. Weak bitter, and slightly saline taste. Soluble in water, leaving gypsum. B.B. fuses on charcoal to an opaque reddish bead, becoming white when cold. Chem. com. sulphates of lime 45, of magnesia 20·5, of potassa 28, and water 5·5. Ischel, Aussee, and Berchtesgaden.

217. GLAUBERITE, Brongniartin.—$\dot{Na}\,\dddot{S} + \dot{Ca}\,\dddot{S}$.

Monoclinohedric; C=68° 16′; ∞P 83° 20′, —P 116° 20′. Crystals $0P\,.\,$—P, with ∞P (fig. 173). Cleavage, basal perfect, along ∞P traces. H.=2·5...3; G.=2·75...2·85. Translucent; vitreous to resinous. Colourless, but yellowish or grayish-white. Taste slightly

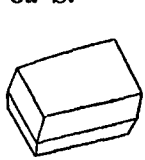


Fig. 173.

saline and bitter. B.B. decrepitates violently, and melts to a clear glass; decomposed by water, which removes the sulphate of soda. Chem. com. 51 sulphate of soda, and 49 sulphate of lime. Villarubia in Spain, Vic, Berchtesgaden; near Brugg in Aargau, Aussee and Ischel in Austria, and Tarapaca in Peru.

218. ALUNITE, Alumstone.—$3\dddot{Al}\,\dddot{S} + \dot{K}\,\dddot{S} + 6\dot{H}$.

Rhombohedric; R. 89° 10'. Crystals, R, or R . 0R (fig. 174); also fine granular, earthy, or compact. Cleavage, basal rather perfect. H.=3·5...4; G.=2·6...2·8. Translucent; vitreous, on 0P pearly. Colourless and white, but grayish, yellowish, or reddish. B.B. infusible alone. Becomes blue with cobalt solution; soluble in warm con. s. acid, not in h. acid. Chem. com. 37·95 alumina, 10·66 potash, 39·42 sulphuric acid, and 11·97 water. Beregszasz in Hungary, Tolfa in the Papal States; also in Tuscany, near Naples, Lipari Islands, Auvergne, Milo, and Argentiera.

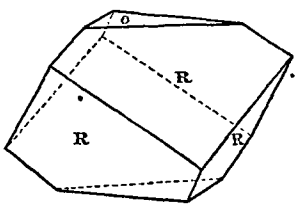


Fig. 174.

219. ALUMINITE, Websterite.—$\dddot{Al}\,\dddot{S} + 9\dot{H}$.

Reniform, and very fine scaly or fibrous. Fracture earthy; sectile or friable. H.=1; G.=1·7. Opaque; dull or glimmering. Snow-white or yellowish-white. In closed tube yields much water. B.B. emits sulphurous fumes, the remainder being infusible; easily soluble in h. acid. Chem. com. 29·8 alumina, 23·2 sulphuric acid, and 47 water. Newhaven in Sussex; Eperney, Auteuil, and Lunel Vieil in France; Halle and Morl in Prussia.

220. PHARMACOLITE.—$\dot{Ca}^3\,\dddot{As} + 6\dot{H}$.

Monoclinohedric; C=65° 4'; ∞P 117° 24', −P 139° 17'. Crystals prismatic; often acicular or capillary, or radiated fibrous crusts. Cleavage, clinodiagonal very perfect; sectile and flexible. H.=2...2·5; G.=2·6...2·8. Trans-

lucent; vitreous; pearly or silky. Colourless and white, but sometimes rose-red or green. Yields water in the closed tube. B.B. fuses to a white enamel; in the inner flame on charcoal gives arsenic fumes, and fuses to a semi-translucent grain, colouring the flame blue; easily soluble in acids. Chem. com. 51 arsenic acid, 25 lime, and 24 water. Andreasberg, Riechelsdorf, Biber, Joachimsthal in Bohemia, Markirchen, and Wittichen in the Schwarzwald.

Picropharmacolite contains magnesia. *Roselite*, vitreous; rose-red. B.B. with borax forms a deep blue glass. Chem. com. arsenic acid, oxide of cobalt, lime, magnesia, and water. Schneeberg in Saxony.

221. HAIDINGERITE.—$\dot{Ca}^2 \dddot{\dot{A}s} + 3\,\dot{H}$.

Rhombic; ∞P 100°. Cleavage very perfect; sectile, flexible. H.=2...2·5; G.=2·8...2·9. Transparent or translucent. Colourless and white. Chem. com. 85·68 arseniate of lime and 14·32 water. Joachimsthal in Bohemia.

222. BERZELIITE.—$\dot{Ca}^3 \dddot{\dot{A}s} + \dot{Mg}^3 \dddot{\dot{A}s}$.

Massive, with traces of cleavage. Brittle. H.=5·5; G.=2·52. Translucent on the edges; resinous. Honey-yellow or yellowish-white. B.B. infusible, but becomes gray; soluble in nitric acid. Contains also 2 to 4 manganese protoxide. Longbanshytta in Sweden.

223. STRUVITE, Guanite.—$(\dot{N}H^4\,\dot{O}, \dot{Mg}^2)\,\dddot{\dot{P}} + 12\,\dot{H}$.

Rhombic and hemihedric; $\bar{P}\infty$ 63° 7′, $P\infty$ 95°. Cleavage, brachydiagonal perfect. H.=1·5...2; G.=1·66...1·75. Transparent or opaque; vitreous. Colourless, but yellow or brown. In the closed tube yields water and ammonia. B.B. fuses to a white enamel; soluble in h. acid, and very slightly in water. Chem. com. 29·9 phosphoric acid, 16·3 magnesia, 10·6 ammonia, and 44 water. Under St Nicolai church at Hamburg, and in guano from Africa.

*Family V.—Rock-Salt.

Crystallization monoclinohedric and rhombic, some tesseral and hexagonal. H.=1...3, but most about 2; G.=1·5 ...3, but generally 2. All soluble in water, and B.B. fusible or decompose. When pure, mostly white, translucent, and vitreous. They are chiefly products of decomposition, and occur especially in the rainless regions, or in lakes not communicating with the sea.

**224. Rock-Salt.—Na Cl.

Tesseral; almost always cubes. Generally granular and fibrous. Cleavage, hexahedral very perfect; fracture conchoidal; rather brittle; yields slightly when scratched with the nail. H.=2; G.=2·1...2·2. Transparent or translucent; vitreous. Colourless or white, but often red, yellow, gray, and rarely blue. Taste saline. In the closed tube decrepitates, and yields a little water. B.B. on charcoal fuses and partly evaporates, partly sinks into the support. With soda fuses to a clear mass, colouring the flame yellow. Very soluble in water. Chem. com. 60 chlorine and 40 sodium, but often with various impurities.

This important mineral is very widely disseminated, either in thick masses, with clay, anhydrite, and gypsum, or as an efflorescence, covering extensive tracts of country. The most celebrated European deposits occur at Wieliczka and other parts of Galicia, in Hungary, Siebenburg, Moldavia, Styria, Salzburg (Hallein), in Tyrol (Hall); also in Bavaria, Wurtemburg, Switzerland (Bex), and Spain, especially at Cardona. In England the chief deposits are in Cheshire, as at Northwich. As an efflorescence it is most abundant on the sandy plains in Brazil, at the foot of the Atlas Mountains in Africa, in Abyssina, in Arabia, and in the Steppes round the Caspian Sea and Lake Ural. Also as a sublimation among the lavas of Vesuvius.

Sylvin, or chloride of potassium, found as a sublimation on Vesuvius, and in the rock-salt of Hallein and Berchtesgaden, agrees in most characters with rock salt (G.= 1·9...2).

*225. ALUM.—$\dot{R}\dddot{S} + (\dddot{Al}, \dddot{Fe})\dddot{S}^3 + 24\dot{H}$.

Tesseral; O, sometimes with $\infty O \infty$ and ∞O. Generally fibrous crusts, or as an efflorescence. Cleavage, octahedral imperfect; fracture conchoidal. H.=2...2·5; G.=1·75... 1·9. Translucent. Colourless and white. Taste sweetish astringent. Easily soluble in water. B.B. generally evolves sulphurous fumes.

(*a.*) *Potash-alum*, with $\dot{R} = \dot{K}$, and 32·52 sulphuric acid, 10·86 alumina, 9·96 potash, and 45·66 water. In the closed tube it fuses, intumesces, and yields much water. In the Silurian alum-slates of Sweden, Norway, and Scotland; the coal formation, Hurlet and Campsie, in Scotland; the lias near Whitby; in the brown-coals of Hessia and the Rhine; and in the volcanic formations of the Lipari Islands, Sicily, and the Azores.

(*b.*) *Ammonia-alum*, with $\dot{R} = NH^4O$, and about 4 per cent. ammonia and 48 water. In the closed tube it forms a sublimate of sulphate of ammonia. Tschermig in Bohemia.

(*c.*) *Soda-alum*, with $\dot{R} = \dot{Na}$, and 7 soda and 48 water. Like potash-alum, but more easily soluble. Near Mendoza in South America, the Solfatara at Naples, and Milo.

(*d.*) *Magnesia-alum.*—$\dot{R} = \dot{Mg}$ with $\dot{Mn}$. Translucent and silky, but soon changes in the air. South Africa, Iquique in Peru (*Pickeringite*).

(*e.*) *Iron-alum* (*Feather-alum*), with $\dot{R} = \dot{Fe}$. Hurlet near Paisley, Mörsfield in Rhenish Bavaria, Krisuvig in Iceland (*Hversalt*).

226. VOLTAITE.—$3\,(\dot{Fe}, \dot{K}, \dot{Na})\dddot{S} + (\dddot{Fe}, \dddot{Al})\dddot{S} + 12\,H$.

Tesseral. Black, brown, or green; greenish-gray streak. Otherwise like alum, but more difficultly soluble in water. Solfatara of Pozzuoli.

227. ALUNOGENE, Halotrichite, Hair Salt.—$\dddot{Al}\ \dddot{S}^3 + 18\ \dot{H}$.

Capillary or acicular, in crusts or reniform masses. H. = 1·5 ...2; G. = 1·6...1·7. Silky. White, inclining to green or yellow. Tastes like alum. B.B. in closed tube intumesces, yields much water, and is infusible. Chem. com. 36·05 sulphuric acid, 15·40 alumina, 48·55 water. Volcanoes of South America, coal and brown coal strata of Germany, and on old walls.

228. MIRABILITE, Glauber-salt.—$\dot{Na}\ \dddot{S} + 10\ \dot{H}$.

Monoclinohedric; C = 72° 15′; ∞P 86° 31′, P 93° 12′. Crystals predominantly 0P and ∞P∞ (fig. 175); but generally efflorescent crusts. Cleavage, orthodiagonal very perfect; fracture conchoidal. H. = 1·5 ...2; G. = 1·4...1·5. Pellucid and colourless; taste cool, saline, and bitter; decomposes readily in the atmosphere, and falls into powder. Gives no precipitate with carbonate of soda. Chem. com. 19·3 soda, 24·7 sulphuric acid, and 56 water.

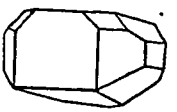


Fig. 175.

As an efflorescence in quarries and on old walls in many countries, on Vesuvius in lava. Used in medicine, and in preparing glass and soap.

N.B.—Nos. 228-236 form a sub-family of *Metallic salts*, or *Vitriols*.

*229. MELANTERITE, Green or Iron Vitriol, Copperas. } $\dot{Fe}\ \dddot{S} + 7\ \dot{H}$.

Monoclinohedric; C = 75° 40′; ∞P (*f*) 82° 21′, −P (*P*) 101° 35′, (P∞) (*o*) 69° 17′, (∞P∞) (*u*), (fig. 176); chiefly stalactitic, reniform, or in crusts. Cleavage, basal very perfect, ∞P less so. H. = 2; G. = 1·8 ...1·9. Translucent, rarely transparent; vitreous. Leek or mountain-green, often with a yellow coating; streak white. Taste sweetish astringent. Very soluble. B.B. becomes

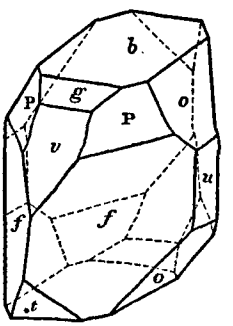


Fig. 176.

brown, then black and magnetic. Chem. com. 26·0 protoxide of iron, 28·8 sulphuric acid, and 45·2 water. Bodenmais, Rammelsberg in the Harz, Fahlun, Schemnitz, Bilin, and Hurlet near Paisley. Used in dyeing, in manufacturing ink, Prussian blue, and sulphuric acid.

230. BOTRYOGENE, Red vitriol. $\dot{Fe}^3 \dddot{S}^2 + 3\dddot{Fe}\,\dddot{S}^2 + 36\,\dot{H}$ (?).

Monoclinohedric; C=62° 26′; ∞P 119° 56′. Crystals small and short prismatic; more common botryoidal and reniform. Cleavage, ∞P rather distinct. H.=2...2·5; G.=2...2·1. Translucent; vitreous. Hyacinth-red, orange-yellow, and yellowish-brown; streak ochre-yellow. Taste slightly astringent. Partially soluble in water, leaving a yellow ochre. Chem. com. sulphates of the protoxide and peroxide of iron (48), with 31 water, and about 21 per cent. sulphates of magnesia and lime; the two latter considered mixtures by Berzelius. Fahlun in Sweden.

231. COPIAPITE.—$\dddot{Fe}^2\,\dddot{S}^5 + 18\,\dot{H}$.

Six-sided tables, but crystal-system uncertain; also granular. Cleavage perfect. Translucent; pearly. Yellow. Chem. com. 30·7 iron peroxide, 38·3 sulphuric acid, and 31 water. Copiapo in Coquimbo in Chili. Also radiated fibrous masses; dirty greenish-yellow, incrusting the former. Contain 32 sulphuric acid, and 37 water; but both are probably mixtures. To these may be added—

Fibroferrite, also from Chili. *Yellow Iron-ore*, from the brown coal at Kolosoruk in Bohemia and Modum in Norway. Both are reniform, or compact and earthy. H.=2·5...3; G.=2·7...2·9. Colour ochre-yellow. Not soluble in water, with difficulty in hydrochloric acid.

Apatelite, reniform earthy, yellow, from Auteuil near Paris, is similar; also *Vitriol ochre* from Fahlun. *Misy*, from Rammelsberg in the Harz, contains sulphates of iron, copper, zinc, and other metals.

232. COQUIMBITE.—$\dddot{Fe}\,\dddot{S}^3 + 9\,\dot{H}$.

Hexagonal; P 58°. Crystals 0P, with ∞P and P; usually

granular. Cleavage, ∞P imperfect. H.=2...2·5; G.=2...2·1. White, also brown, yellow, red, and blue. Taste astringent. Chem. com. 28·5 iron peroxide, 43·6 sulphuric acid, and 28·9 water. Copiapo in Chili, and Calama in Bolivia.

233. TECTIZITE.—$\dddot{\dot{F}}e$, $\dddot{\dot{S}}$, $\dot{H}$.

Rhombic; dimensions unknown. H.=1·5...2; G.=2 nearly. Vitreous or resinous. Clove-brown. Saxony near Schwarzenberg, and at Bräunsdorf.

*234. CYANOSE, Blue Vitriol.—$\dot{C}u\,\dddot{S} + 5\,\dot{H}$.

Triclinohedric. Crystals very unsymmetric; $\infty\breve{P}\infty$ (*n*) to $\infty\breve{P}\infty$ (*r*), forms an angle of 79° 19′; P′ (*P*) to ∞P′ (*T*) 127° 40′, to $\infty\breve{P}\infty$ (*n*) 120° 50′, to $\infty\breve{P}\infty$ (*r*) 103° 27′, and ∞P′ (*T*) to ∞′P (*M*) 123° 10′ (fig. 177). More often stalactitic, reniform, or as an incrustation. Cleavage, along ∞P′ and ∞′P very imperfect; fracture conchoidal. H.=2·5; G.=2·2...2·3. Translucent; vitreous. Blue. Taste very nauseous. Readily soluble in water, from which metallic copper is precipitated by iron. B.B. on charcoal, especially with soda, is easily reduced to metallic copper. Chem. com. 32 protoxide of copper, 32 sulphuric acid, and 36 water. Abundant in the water of some mines, as in the Harz, Hungary, Tyrol, Fahlun, in Anglesea, Cornwall, and Wicklow. Also on the lava of Vesuvius. Used in dyeing, and in forming blue and green pigments.

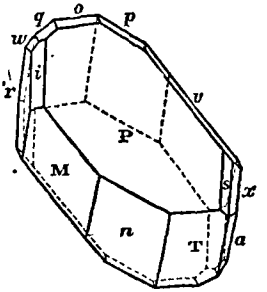
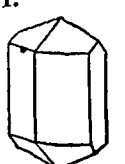


Fig. 177.

*235. GOSLARITE, White Vitriol.—$\dot{Z}n\,\dddot{S} + 7\,\dot{H}$.

Rhombic; ∞P 90° 42′, isomorphous with epsomite; ∞P . $\infty\breve{P}\infty$. P (fig. 178). Mostly granular, or stalactitic, reniform, and encrusting. Cleavage, brachydiagonal perfect. H.=2...2·5; G.=2...2·1. Pellucid; vitreous. White, inclining to gray, yellow, green, or red. Taste nauseous


Fig. 178.

astringent. Chem. com. 28·2 zinc oxide, 27·9 sulphuric acid, and 43·9 water. Rammelsberg in the Harz, Fahlun, Schemnitz, Holywell in Flintshire, in Cornwall, at Villefranche, and Guipuzcoa in Spain. Used in dyeing and medicine.

236. BIEBERITE, Cobalt Vitriol.—$(\dot{C}o, \dot{M}g)\,\ddot{\ddot{S}} + 7\,\dot{H}$.

Monoclinohedric; similar to melanterite; usually stalactitic, or an efflorescence. Pale rose-red. Taste astringent. Chem. com. 20 cobalt oxide, 4 magnesia, 29 sulphuric acid, and 47 water. Bieber near Hanau, and Leogang in Salzburg.

237. JOHANNITE, Uran Vitriol.

Monoclinohedric; C = 85° 40′; ∞P 69°. Crystals similar to trona (fig. 181), but very small. Cleavage, ∞P. H. = 2 ...2·5; G. = 3·19. Semitransparent; vitreous. Bright grass-green, with paler streak. Chem. com. a hydrous sulphate of the protoxide of uranium. Joachimsthal and Johann-Georgenstadt.

*238. NATRON.—$\dot{N}a\,\ddot{C} + 10\,\dot{H}$.

Monoclinohedric; C = 57° 40. Crystals (∞P∞). ∞P. P. ∞P∞ (fig. 179); with ∞P (*M*) 79° 41, P (*P*) 76° 28′. Cleavage, ∞P∞ distinct; (∞P∞) less so. H. = 1...1·5; G. = 1·4...1·5. Pellucid; vitreous. Colourless or grayish-white. B.B. melts easily, colouring the flame yellow. Chem. com. 2·18 soda, 15·4 carbonic acid, and 6·28 water; but mixed with chloride of sodium, and other salts. On lava, as on Vesuvius and Etna; as an efflorescence on the ground in Hungary, Egypt, Tartary, and in mineral springs and lakes. Used in the manufacture of soap, in dyeing, bleaching, and medicine.

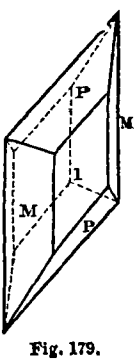


Fig. 179.

239. THERMONATRITE.—$\dot{N}a\,\ddot{C} + \dot{H}$.

Rhombic; $\breve{\infty}\breve{P}2$ (*d*) 107° 50′, $\breve{P}\infty$ (*o*) 83° 50′; with $\infty\breve{P}\infty$

(P), in rectangular tables (fig. 180). Cleavage, (*p*) perfect. H.=1·5; G.=1·5...1·6. Colourless. B.B. like natron, but does not melt. Chem. com. 50·1 soda, 35·4 carbonic acid, and 14·5 water. Natron lakes of Lagunilla in Colombia, of Lower Egypt, and of the steppes between the Ural and Altai.

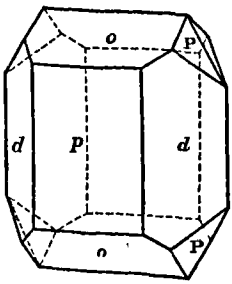


Fig. 180.



Fig. 181.

240. TRONA, Urao.—$\dot{N}a^2\,\ddot{C}^3+4\,\dot{H}$.

Monoclinohedric. Crystals 0P and $\infty P\infty$ (103° 15′), (fig. 181). Cleavage, $\infty P\infty$ perfect. H.=2·5...3; G.=2·1...2·2. Transparent to translucent; colourless. Does not decompose in the air. Taste alkaline. Chem. com. 37·93 soda, 40·24 carbonic acid, and 21·83 water. Fezzan and Barbary (*Trona*), Lagunilla in Colombia (*Urao*).

241. GAYLUSSITE.—$\dot{N}a\,\ddot{C}+\dot{C}a\,\ddot{C}+5\,\dot{H}$.

Monoclinohedric; C=78° 27′; ∞P 68° 51′, P 110° 30′. Cleavage, ∞P imperfect; fracture conchoidal. H.=2·5; G.=1·9...1·95. Transparent; vitreous; colourless. Slowly and partially soluble in water. B.B. fuses readily to an opaque bead. Chem. com. 34·5 carbonate of soda, 33·6 carbonate of lime, 30·4 water, with 1·5 clay. Lagunilla near Merida.

*242. BORAX, Tinkal.—$\dot{N}a\,\dddot{B}^2+10\,\dot{H}$.

Monoclinohedric; C=73° 25′; ∞P 87°, P 122° 34′; almost isomorphous with augite. Twin crystals frequent. Cleavage, ($\infty P\infty$) perfect; ∞P less distinct; fracture con-

choidal, rather brittle. H.=2...2·5; G.=1·7...1·8. Pellucid; resinous. Colourless, but yellowish, greenish, and grayish-white. Taste feebly alkaline and sweetish. B.B. intumesces greatly, becomes black, and melts to a transparent bead, colouring the flame yellow, or, with sulphuric acid, green; soluble in 12 parts of cold water. Chem. com. of the pure salt, 16·37 soda, 36·53 boracic acid, and 47·10 water; but often contains many impurities. Shore of salt lakes in Thibet and Nepal, and in South America near Potosi. Borax is prepared from this mineral, and is used for blowpipe experiments, in preparing fine glass, in medicine, and for dyeing.

*243. SASSOLINE.—$\dddot{B}+3\dot{H}$.

Triclinohedric; 0P: $\breve{\infty}P\breve{\infty}$ 75° 30′; usually fine scaly six-sided tables, or fibrous, and stalactitic. Macles frequent. Cleavage, basal very perfect; sectile and flexible. H.=1; G.=1·4...1·5. Translucent; pearly. Grayish or yellowish-white. Taste acidulous and slightly bitter. Feels greasy. Easily soluble in boiling, less so in cold water. Frothes up and melts in the candle flame to a hard transparent glass, colouring the flame green. Chem. com. 56·3 boracic acid, and 43·7 water. Vulcano in the Lipari Islands, hot springs of Sasso near Sienna, and lagoni of Tuscany.

*244. NITRE, Salpetre.—$\dot{K}\,\dddot{N}$.

Rhombic; ∞P (*M*) 119°, $2\breve{P}\infty$ (*P*) 71°, $\breve{P}\infty$ 110°, $\infty\breve{P}\infty$ (*h*), (fig. 182); isomorphous with arragonite. Only occurs acicular, capillary, or pulverulent. Cleavage indistinct; fracture conchoidal. H.=2; G.=1·9...2. Semitransparent; vitreous, or silky. Colourless, white or gray. Taste saline and cooling. Deflagrates when placed on hot charcoal; and B.B. on platina wire melts very easily, colouring the flame violet. Chem. com. 46·6 potash, and 53·4 nitric acid, but always

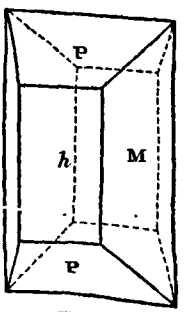


Fig. 182.

more or less mixed. In the limestone caves of many countries, Hungary, Spain, India. Used for producing nitric acid, in glass-making, medicine, and the manufacture of gunpowder.

245. NITRATINE.—$\dot{N}a\,\dddot{\dot{N}}$.

Rhombohedric; R = 106° 30′, isomorphous with dolomite. Cleavage rather perfect. H. = 1·5...2; G. = 2·1 ...2·2. Translucent or transparent, with very distinct double refraction; vitreous. Colourless, or grayish and yellowish-white. Taste saline and cooling. Deflagrates on hot charcoal. B.B. fuses on platina wire, colouring the flame yellow. Chem. com. 36·6 soda, and 63·4 nitric acid, but mixed with common salt and other substances. Tarapaca in Chili. Used in the arts as a substitute for nitre; but deliquesces in the air.

246. NITROCALCITE.—$\dot{C}a\,\dddot{\dot{N}} + \dot{H}$

Fibrous or pulverulent. White or gray. Translucent. Taste sharp and bitter. Readily soluble in water, and deliquesces in the air; melts slowly on burning charcoal, with slight detonation. Chem. com. 30·8 lime, 59·3 nitric acid, and 9·9 water. Limestone caves of Kentucky; on old walls and limestone rocks.

247. NITROMAGNESITE.—$\dot{M}g\,\dddot{\dot{N}} + \dot{H}$.

In the same places, and similar to nitrocalcite. Taste bitter. Chem. com. 24 magnesia, 65 nitric acid, and 11 water.

*248. SAL-AMMONIAC.—$N\,H^4\,Cl$.

Tesseral; O, also $\infty O\infty$, ∞O, and $3O3$. In crusts, stalactites, and earthy or pulverulent. Cleavage, O imperfect; fracture conchoidal. H. = 1·5...2; G. = 1·5...1·6. Pellucid; vitreous. Colourless, but gray or yellow, rarely green, brown, or black. Taste saline and pungent. B.B. volatilizes without fusing; on copper wire colours the flame bluish-green. Chem. com. (32 per cent. ammonia, or) 33·9 ammonium, and 66·1 chlorine. Chiefly occurs as a sublimate on active volcanoes, Vesuvius, Etna, the Solfatara,

Vulcano, and Iceland; also near ignited coal seams, Newcastle, and Scotland. Used in medicine, dyeing, and various metallurgic operations.

249. MASCAGNINE.—$N H^3 \dddot{S} + \dot{H}$.

Rhombic; ∞P 107° 40′, $\breve{P}\infty$ 121° 16′; $\infty P \cdot \infty \breve{P} \infty \cdot P$ (fig. 183); but chiefly in crusts and stalactites. Cleavage rather perfect; sectile. H.=2...2·5; G.=1·7...1·8. Pellucid, vitreous. Colourless, white or yellowish. Taste pungent and bitter; easily soluble, and deliquesces. B.B. decrepitates, melts, and volatilizes. Chem. com. 25·9 ammonia, 60·5 sulphuric acid, and 13·6 water. Near volcanoes, as Etna, Vesuvius, the Solfatara, the Lipari Islands, in the lagoni near Sienna, and in ignited coal beds, as at Bradley in Staffordshire.

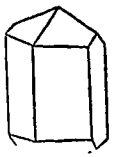


Fig. 183.

250. ARCANITE, Glaserite.—$\dot{K} \dddot{S}$.

Rhombic; acute pyramids, with ∞P 120° 24′, $2 \breve{P} \infty$ 67° 38′, $0P$, and other forms. Mostly in crusts, or pulverulent. Cleavage, basal imperfect. H.=2·5...3; G.=2·73. Pellucid; vitreous or resinous. Colourless or white. Taste saline, bitter. B.B. decrepitates, fuses, and becomes hepatic. Chem. com. 54·04 potash and 45·96 sulphuric acid. Lavas of Vesuvius and other volcanoes.

251. THENARDITE.—$\dot{Na} \dddot{S}$.

Rhombic; acute pyramids P, with $0P$ and ∞P, in crusts and druses. Cleavage, basal rather perfect; fracture uneven. H.=2·5; G.=2·6...2·7. Pellucid, vitreous. White. Taste feebly saline. B.B. colours the flame deep yellow, and fuses. Chem. com. 43·82 soda, and 56·18 sulphuric acid. Salinas d'Espartinas near Aranjuez, and Tarapaca. Used for preparing soda.

252. LOWEITE.—$2 (\dot{Na} \dddot{S} + \dot{Mg} \dddot{S}) + 5 \dot{H}$.

Compact, with traces of one cleavage. H.=2·5...3; G.=2·376. Vitreous. Yellowish-white to flesh-red. Taste

slightly saline. Chem. com. 20·3 soda, 13·2 magnesia, 52 sulphuric acid, and 14·5 water. Ischel.

*253. Epsomite, Epsom-salt.—$\dot{M}g\,\ddot{S} + 7\,\dot{H}$.

Rhombic; P mostly hemihedric, ∞P 90° 38′; ∞P (*M*). $\infty \breve{P} \infty$ (*o*). P (*l*) (fig. 184). Granular, fibrous, or earthy. Cleavage, brachydiagonal perfect. H. = 2...2·5; G. = 1·75. Pellucid; vitreous; and white. Taste saline, bitter. B.B. on charcoal fuses, incandesces, and shows alkaline reaction; with solution of cobalt becomes pale rose-red. Chem. com. 16·32 magnesia, 32·53 sulphuric acid, and 51·15 water. Efflorescence on various rocks, as at Hurlet near Paisley, Idria, Montmartre, and Freiberg; on the ground in Spain, and the Russian steppes; in mineral waters, as at Epsom in Surrey (Epsom salts), Saidschütz and Seidlitz in Bohemia. Used in medicine and in preparing magnesia.

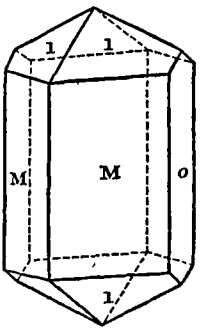


Fig. 184.

Astrakanite.—White, transparent, prismatic crystals among the salts in the salt lakes near the Wolga. Chem. com. 41·00 sulphate of soda, 35·18 sulphate of magnesia, 21·56 water. *Reussin*, white, six-sided, and pointed crystals, from Seidlitz and Saidschütz in Bohemia, is similar, but seems a mixture.

ORDER III.

SALINE ORES.

Resemble the saline stones both in external characters and chemical composition, forming almost a parallel series, with metallic oxides in place of the earthy bases. Lime or magnesia occasionally occur in more or less extent, and the acid element is one of the common acids of the chemist. Crystallization in the carbonates is often rhombohedric, in the others monoclinohedric or rhombic. Other systems only occur in rare cases.

Hardness is not high, mostly 3...4, in a few as high as 5, and as low as 2. Their specific gravity is high, from the metallic element in their composition; mostly from 3...4 in the salts of iron or copper, and from 5...7 or 8 in the salts of lead and some others. They are almost all soluble in acids, and the carbonates effervesce. B.B. mostly fusible, decomposed, or reduced, and with fluxes form coloured glasses characteristic of the different metals. They are mostly translucent, rarely transparent. Their lustre is often pearly or vitreous. Some are white, others are coloured, and these colours are now characteristic of the metal as the essential element.

*Family I.—The Sparry Iron Ores.

Crystallization and cleavage rhombohedric. H.=3·5...5; G.=3·3...4·5. They are all soluble in acids, and often effervesce. B.B. they are all infusible, but decomposed, and leave a magnetic residue, and show reactions of metals. The colours are white, but often with a brown, yellow, or

red tinge, especially when weathered. They chiefly occur in veins.

*254. SIDERITE, Sparry Iron, Sphärosiderite, Chalybite. } $\dot{Fe}\ddot{C}$.

Rhombohedric; R 107°. Chiefly R, often curved, saddle-shaped, or lenticular, occasionally 0R, $-\frac{1}{2}$R, ∞R, -2R, ∞P2. Frequently fine or coarse granular, more rarely botryoidal or reniform (*Sphærosiderite*). Cleavage, rhombohedral along R perfect. H.=3·5...4·5; G.=3·7...3·9. Translucent in various degrees, becoming opaque when weathered; vitreous or pearly. Rarely white, generally yellowish-gray or yellowish-brown, changing to red or blackish-brown on exposure. B.B. infusible, but becomes black and magnetic; with borax and salt of phosphorus shows reaction for iron; with soda usually for manganese. In acids soluble with effervescence. Chem. com. carbonate of iron, with 62·6 protoxide of iron and 37·9 carbonic acid, but usually 0·5 to 10, or even 25 protoxide of manganese, 0·2 to 15 magnesia, and 0·1 to 2 lime. In beds or masses, in Styria, Carinthia, and Westphalia; in veins in Anhalt and the Harz; also in the Pyrenees, and the Basque provinces of Spain, as near Bilboa. In crystals at Joachimsthal, Freiberg, Klausthal, Beeralstone in Devonshire, Alston Moor in Cumberland, and in many of the tin mines of Cornwall.

Clay ironstone, gray, blue, brown, or black, G.=2·8... 3·5; H.=3·5...4·5, is an impure variety. It occurs chiefly in slate-clay or marls, in layers or nodular masses, especially in the coal formation of Britain, Belgium, and Silesia. These ores contain 50 to 85 per cent. carbonate of iron, and yield 25 to 42 metal. The Lanarkshire black-band contains 70 carbonate of iron, 23 carbonaceous matter, 7 of silica, alumina, and lime, and yields 33·7 iron. In 1855 Great Britain produced 3,217,000 tons iron, worth about twelve millions sterling. South Wales alone produced about 839,000 tons, and Scotland 828,000 tons, worth nearly three millions sterling.

Junkerite, from Brittany, is a mere variety of siderite. *Oligon spar*, varieties with more than 20 per cent. manganese protoxide.

Ankerite.—R 106° 12′, but mostly massive and granular. G. = 2·9...3·1; otherwise like siderite. Contains 51 carbonate of lime, 12 to 33 carbonate of magnesia, 12 to 36 carbonate of iron, and 0 to 3 carbonate of manganese protoxide. Styria. Used as an ore or flux.

255. DIALLOGITE, Red Manganese.—$\dot{Mn}\,\ddot{C}$.

Rhombohedric; R 106° 51′; R and $-\frac{1}{2}$R, sometimes 0R and ∞P 2. Crystals often curved, lenticular, or saddle-shaped; also spherical, reniform, and columnar or granular. Cleavage, R perfect. H. = 3·5 ... 4·5; G. = 3·3 ... 3·6. Translucent; vitreous or pearly. Rose-red to flesh-red; streak white. B.B. usually decrepitates and becomes greenish-gray or black, but is infusible; the powder soluble with effervescence in warm h. acid. Chem. com. 62 manganese protoxide and 38 carbonic acid, but usually mixed with carbonates of lime 0 to 13, magnesia 0 to 7, or iron 0 to 15. Freiberg, Schemnitz, Kapnik, Nagyag, Elbingerode, and near Sargans. At the latter, also hydrated, and fibrous, silky (*Wiserite*); compact in Hessia and Glendree, Ireland.

256. MANGANOCALCITE.—$(\dot{Mn}, \dot{Ca}, \dot{Fe})\,\ddot{C}$.

Rhombic; in prisms like arragonite, and bears the same relation to diallogite that arragonite does to calc-spar. H. = 4... 5; G. = 3·03. Red or reddish-white; vitreous. Schemnitz.

257. LANTHANITE.—$\dot{La}\,\ddot{C} + 3\,\dot{H}$.

Rhombic; ∞P 94° nearly; small tabular crystals; usually granular or earthy. Cleavage basal. H. = 2·5...3; G. = 2·7. Dull or pearly. White or yellowish. B.B. becomes brownish-yellow; soluble in acids with effervescence. Chem. com. 21·1 carbonic acid, 52·9 lanthanium oxide, and 26 water. Bastpæs in Sweden, Lehigh in Pennsylvania.

258. PARISITE.—$\dot{Ce}\,\ddot{C}$, Ca F, $\dot{H}$.

Hexagonal; P 164° 58′. Cleavage, basal very perfect.

H.=4·5; G.=4·35. Vitreous; on the cleavage planes pearly. Brownish-yellow inclining to red. B.B. infusible and phosphorèsces. Chem. com. 23·6 carbonic acid, 60 protoxide of cerium, with lanthanium and didymium, 3·17 lime, 11·51 fluoride of calcium, and 2·4 water. Emerald mines of the Musso Valley in New Granada.

*259. CALAMINE, Smithsonite.—$\dot{Z}n\ \ddot{C}$.

Rhombohedric; R 107° 40′; R, 4 R, and R^3. The crystals generally small, obtuse-edged, and rounded. Usually reniform, stalactitic, and laminar or granular. Cleavage, R perfect but curved; fracture uneven conchoidal; brittle. H.=5·0; G.=4·1...4·5. Translucent or opaque; pearly or vitreous. Colourless, but often pale grayish-yellow, brown, or green. B.B. becomes white, and acts like zinc oxide; soluble in acids with effervescence; also in solution of potash. Chem. com. 64·6 zinc oxide, and 35·4 carbonic acid, but with protoxide of iron 2 to 3, and manganese 3 to 7, lime 1 to 2, or magnesia 0 to 3.

This mineral occurs in beds or veins in the crystalline and transition rocks, and also in the carboniferous and oolite formations. It is most common in limestone, and is often associated with calc-spar, quartz, blende, and ores of iron and lead. Chessy near Lyons, Altenberg near Aix-la-Chapelle, Brillon in Westphalia, Tarnowitz in Silesia, Hungary, Siberia; also Mendip in Somersetshire, Matlock in Derbyshire, Wanlockhead and Leadhills in Scotland; compact at Alston Moor. Zinc is obtained chiefly from this mineral by distillation. In Silesia also cadmium.

Kapnite.—Varieties with 15 to 37 per cent. of iron protoxide.

Zinc-bloom.—Reniform, earthy, pale-yellow, and shining streak; seems a mere produce of decomposition. Bleiberg and Raibel in Carinthia.

Herrerite.—Rhombohedric, with curved cleavage planes. H.=4..,5; G.=4·3. Translucent; pearly or vitreous; green. B.B. becomes gray, fumes, and stains the charcoal

white. Consists, according to Del Rio, of carbonates of zinc oxide and nickel oxide. Mexico.

*260. GALMEI, Electric Calamine.—$\dot{Z}n^2\ddot{S}i + \dot{H}$.

Rhombic, and hemimorphic; $2\breve{P}2$ (*P*) with polar edges 101° 44′, and 132° 16′; ∞P (*d*) 104° 6′, $\bar{P}\infty$ (*o*) 117° 8′, $\breve{P}\infty$ (*l*) 129° 2′; common form $\infty\breve{P}\infty$ (*s*) . ∞P . $\bar{P}\infty$ (fig. 185). Also columnar, fibrous, granular, and earthy. Cleavage, prismatic along ∞P very perfect, along $\bar{P}\infty$ perfect. H.=5; G.=3·3...3·5. Transparent to translucent; vitreous and pearly. Colourless or white, but often light gray, also yellow, green, brown, and blue; becomes electric by heat. B.B. decrepitates slightly, but is infusible; readily soluble in acids, and gelatinizes. Chem. com. 25·7 silica, 66·8 zinc oxide, and 7·5 water. With calamine, as at Raibel and Bleiberg in Carinthia, Aix-la-Chapelle, Iserlohn, Tarnowitz, and Nertschinsk; also Mendip Hills, Matlock in Derbyshire, and Wanlockhead. Used as an ore of zinc, and in the manufacture of brass.

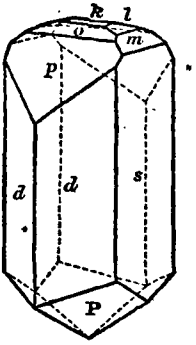


Fig. 185.

261. WILLEMITE, Troostite.—$\dot{Z}n^2\ddot{S}i$.

Rhombohedric; R 115°; $\infty P2$. R; also granular and reniform. Cleavage, basal rather perfect, ∞ R imperfect; brittle. H.=4·5; G.=4·1...4·2. Translucent or transparent; dull resinous. White, yellowish, or brown. B.B. in closed tube yields no water, otherwise like galmei. Chem. com. 72·47 zinc oxide and 27·53 silica, with 0 to 9 protoxide of manganese, 0 to 5 iron protoxide, and 0 to 3 magnesia. Aix-la-Chapelle, Liege, Raibel, and Sterling and Franklin in New Jersey.

Family II.—Iron Salts.

Crystallization predominantly rhombic or monoclinohedric. H. = 2...5·5; G. = 2·2...4. They are all soluble in acids, and many easily. B.B. all fusible, and also often easily so. Their colours are often brown, or dark blue and dark green; the streak yellow or red. They are chiefly phosphates or arseniates of iron. The phosphates B.B., moistened with sulphuric acid, colour the flame bluish-green. The arseniates B.B. in the reducing flame, or with carbonate of soda, evolve odour of arsenic.

*262. Vivianite, Blue Iron. $\left.\begin{matrix}\\\\\end{matrix}\right\}$ $6\ (\dot{F}e^{3}\dddot{P}+8\dot{H})+(\dddot{F}e^{3}\dddot{P}^{2}+8\dot{H})$.

Monoclinohedric; C = 71° 25′, ∞P 111° 12′, P 119° 10′, P∞ 54° 13′. Crystals (∞P∞) . ∞P∞ . P∞ (fig. 186); also spherical or reniform, and fibrous or earthy. Cleavage, clinodiagonal very perfect; thin laminæ flexible. H. = 2; G. = 2·6...2·7. Translucent or transparent; vitreous or bright pearly on cleavage. Indigo-blue to blackish-green; streak bluish-white, but soon becomes blue on exposure. The white earthy variety also changes to blue in the air; the dry crushed powder is liver-brown. In the closed tube yields much water, intumesces, and becomes spotted with gray and red. B.B. on charcoal becomes red, and then fuses to a gray, shining, magnetic granule; easily soluble in h. or nitric acid; becomes black in warm solution of potash. Chem. com., the colourless vivianite is a hydrous phosphate of iron protoxide, with 42 iron protoxide, 29 phosphoric acid, and 29 water; but on exposure, when it acquires a blue colour, with 29·1 phosphoric acid, 33·0 iron protoxide, 12·2 iron peroxide, and 25·7 water. Transparent indigo-coloured crystals at St Agnes in Cornwall, and Allentown and Imleytown in New Jersey. Earthy in Cornwall, Styria, North America, Greenland, and New

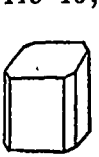


Fig. 186.

Zealand, and in peat mosses in Northern Germany, Sweden, Norway, and the Zetland Isles. As a recent formation under some old slaughter-houses at the foot of the Castle Rock in Edinburgh. It is sometimes used as a pigment. *Mullicite* and *Anglarite* are varieties.

263. DUFRÉNITE, Green Iron Earth.—$2\,\dddot{\dot{F}}e^2\,\ddot{\dot{P}} + 5\,\dot{H}$.

Rhombic; ∞P about 123°; spherical or reniform. Cleavage brachydiagonal; very brittle. H.=3...3·5; G.=3·3 ...3·4. Translucent on the edges, or opaque; shining or dull. Dirty, leek, or blackish green; streak siskin-green. B.B. fuses readily to a porous, black, non-magnetic globule; soluble in h. acid. Chem. com. 63 iron peroxide, 28 phosphoric acid, and 9 water. Westerwald, Hirschberg, and Limoges in France.

264. TRIPLITE.—$\dot{Mn}^4\,\ddot{\dot{P}} + \dot{Fe}^4\,\ddot{\dot{P}}$.

Rhombic (?); only granular. Cleavage, in three directions at right angles; fracture conchoidal. H.=5...5·5; G.=3·6...3·8. Translucent or opaque; resinous. Chesnut or blackish-brown; streak yellowish gray. B.B. on charcoal fuses easily, with strong intumescence, to a black magnetic globule; soluble in h. acid. Chem. com. 34 iron protoxide, 33 manganese protoxide, and 33 phosphoric acid. Limoges in France.

265. ZWIESELITE, Eisenapatit.—$(\dot{Fe}, \dot{Mn})^3\,\ddot{\dot{P}} + Fe\,F$.

Rhombic (?), but only massive. Cleavage, in three directions imperfect; fracture conchoidal. H.=4·5...5; G.=3·95...4. Translucent on the edges; resinous. Colour brown; streak yellow. B.B. decrepitates and fuses easily to a bluish-black magnetic globule; easily soluble in warm s. acid, showing traces of fluorine. Chem. com. 30·3 phosphoric acid, 41·4 iron protoxide, 23·3 manganese protoxide, and 6 fluorine. Zwiesel in Bavaria.

266. TRIPHYLINE.—$6\,(\dot{Fe}^3, \dot{Mn}^3)\,\dddot{\dot{P}} + \dot{Li}^3\,\dddot{\dot{P}}$.

Rhombic; ∞P 94°; chiefly granular. Cleavage, basal

perfect, prismatic and diagonal imperfect. H.=5; G.=3·6. Translucent on the edges; resinous. Greenish-gray with blue spots. B.B. fuses very easily to a dark steel-gray magnetic bead; easily soluble in h. acid. Chem. com. 42·64 phosphoric acid, 49·16 iron protoxide, 4·75 manganese protoxide, and 3·45 lithia. Bodenmais in Bavaria. *Tetraphyline* or *Petrowskine*, from Tammela in Finland, is similar.

267. MONAZITE, Mengite.—$(\dot{C}e, \dot{L}, \dot{T}h)^3 \dddot{P}$.

Monoclinohedric; C=77°, ∞P 94° 35′; crystals of 0P . ∞P . (∞P∞) . P∞ . −P∞, with 0P : P∞ = 129° 6′, 0P : −P∞ = 139° 25′ (fig. 187); thick, tabular, or very short prismatic. Cleavage, basal imperfect. H.=5...5·5; G.=4·9...5·25. Translucent on the edges; dull resinous. Flesh-red, hyacinth-red, and reddish-brown. B.B. infusible; moistened with sulphuric acid, colours the flame green; soluble in h. acid. Chem. com. 28 phosphoric acid, 25 to 37 cerium protoxide, 23 to 27 lanthanium oxide (18 thorina), with 2 tin oxide, 1·5 lime, and some magnesia and manganese. Miask in Ural, and Norwich in Connecticut (*Edwardsite*).

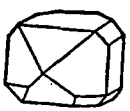


Fig. 187.

Monazitoid.—G.=5·281; brown; partially soluble in acids, and with 18 phosphoric acid; probably a variety.

268. CRYPTOLITE.—$\dot{C}e^3 \dddot{P}$.

Acicular crystals, imbedded in apatite. G.=4·6. Transparent. Pale wine-yellow. Soluble as powder in con. s. acid. Wöhler's analysis gave 73·70 cerium oxide (protoxide), 27·37 phosphoric acid, and 1·51 iron protoxide. Arendal.

269. HUREAULITE.—$(\dot{M}n, \dot{F}e)^5 \ddot{\dddot{P}}^2 + 8\,\dot{H}$.

Monoclinohedric; C=68°, ∞P 62° 30′, P 88°; fracture conchoidal. H.=3·5; G.=2·27. Translucent; resinous. Reddish-yellow or brown. B.B. fuses easily to a black metallic globule; soluble in acids. Chem. com. 38 phos-

phoric acid, 11·1 iron protoxide, 32·9 manganese protoxide, and 18 water. Hureaux near Limoges.

Beraunite.—Foliated and radiated. H.=2; G.=2·87. Vitreous or pearly. Hyacinth-red or reddish-brown; streak reddish ochre-yellow. B.B. in forceps melts and colours the flame bluish-green; soluble in h. acid. Seems a hydrous phosphate of iron. Beraun in Bohemia. *Kakoxene*, from Zbirow in Bohemia, is similar.

Heterozite.—H.=5; G.=3·5. Opaque, or translucent on the edges; vitreous or resinous. Colour dark-violet or lavender-blue to greenish-gray; streak violet-blue or crimson-red. Chem. com. 41·77 phosphoric acid, 34·89 iron protoxide, 17·57 manganese protoxide, and 4·40 water. Hureaux near Limoges.

270. ALLUAUDITE.—$(\dot{M}n, \dot{N}a)^3 \ddot{\dot{P}} + \ddot{\dot{F}}e \ddot{\dot{P}} + \dot{H}$.

Rhombic, with cleavage in three directions at right angles. H. above 4; G.=3·468. Translucent on the edges; lustre dull. Clove-brown; streak yellowish-brown. B.B. on platina wire fuses to a black magnetic globule; in h. acid forms a black solution. Chem. com. 41·25 phosphoric acid, 25·62 peroxide of iron, 23·08 manganese protoxide, 1·06 manganese peroxide, 5·47 soda, 2·65 water, and 0·60 silica. Chanteloube near Limoges.

271. DIADOCHITE.—$\ddot{\dot{F}}e \ddot{\dot{P}}^2 + 4\ \ddot{\dot{F}}e \ddot{\dot{S}} + 32\ \dot{H}$.

Reniform and stalactitic. Fracture conchoidal. H.=3; G.=2·035. Resinous; vitreous. Yellow or yellowish-brown; streak white. B.B. intumesces, and fuses on the edges to a black magnetic enamel. Chem. com. 36·7 iron peroxide, 14·8 phosphoric acid, 15·2 sulphuric acid, and 30·3 water. Grafenthal and Saalfeld in Thuringia.

272. DELVAUXINE.—$\ddot{\dot{F}}e^2 \ddot{\dot{P}} + 24\ \dot{H}$.

Massive and earthy. H.=2·5; G.=1·85. Reddish or blackish brown or yellow. B.B. decrepitates, and fuses to a gray magnetic bead. In h. acid forms a brown solution.

Chem. com. 35·8 iron peroxide, 48·3 water, and 15·9 phosphoric acid. Visé in Belgium.

Kærphosiderite, reniform, opaque, resinous, and straw-yellow, with a greasy feel, is related. H.=4·5; G.=2·5. B.B. becomes red and fuses to a black magnetic bead; consists of hydrous phosphate of iron with a little oxide of zinc. Labrador.

273. PISSOPHANE.—$(\dddot{A}l, \dddot{F}e)^2\ \ddot{S} + 15\dot{H}$.

Stalactitic; fracture conchoidal; very easily frangible. H.=2; G.=1·9...2. Transparent or translucent; vitreous. Olive-green to liver-brown; streak greenish-white to pale yellow. B.B. becomes black; easily soluble in h. acid. Chem. com. 7 to 35 alumina, 10 to 40 iron peroxide, 12 sulphuric acid, and 41 water. Saalfeld, and Reichenbach in Saxony.

274. PITTICITE, Iron Sinter.—$\dddot{F}e^2\ \ddot{S}^3 + 2\ \dddot{F}e\ \ddot{A}s + 24\dot{H}$.

Reniform and stalactitic; brittle; fracture conchoidal. H.=2...3; G.=2·3...2·5. Translucent, or on the edges; resinous, inclining to vitreous. Yellowish, reddish, or blackish-brown, sometimes in spots or stripes; streak light-yellow, or white. B.B. on charcoal fuses easily, with effervescence and strong arsenical fumes, to a black magnetic globule; easily soluble in h. acid to a yellow fluid. Chem. com. 35 iron peroxide, 26 arsenic acid, 14 sulphuric acid, and 24 water. In many old mines, as Freiberg and Schneeberg.

275. SYMPLESITE.

Monoclinohedric, like gypsum; in very fine prismatic crystals or groups. Cleavage perfect. H.=2·5; G.=2·957. Transparent or translucent; vitreous, pearly on the cleavage. Pale indigo to celadine-green, with bluish-white streak. B.B. emits arsenic odours, becomes black and magnetic, but does not fuse. Chem. com. arseniate of iron protoxide with water, also a little sulphuric acid and protoxide of manganese. Lobenstein in Reuss.

276. SCORODITE, Neoctese.—$\dddot{F}e\ \ddot{A}s + 4\dot{H}$.

Rhombic; P, with polar edges 103° 5′ and 114° 34′. Crys-

tals $\infty\breve{P}\infty$ and $\infty\breve{P}\infty$ (r); also 0P (h), $\infty\breve{P}2$ (d) 120° 10, and 2 $\bar{P}\infty$ (m) 48° (fig. 188); also columnar and fibrous. Cleavage imperfect; rather brittle. H.=3·5 ...4; G.=3·1...3·2. Translucent; vitreous. Leek-green to greenish-black, also indigo-blue, red and brown. In closed tube yields water and becomes yellow. B.B. on charcoal fuses easily, emitting arsenic vapours, to a gray magnetic slag; easily soluble in h. (not in nitric) acid, forming a brown solution. Chem. com. 49·8 arsenic acid, 34·6 iron peroxide, and 15·6 water. St Austle in Cornwall, Vaulry in France, Schlackenwald and Schönfeld in Bohemia, Antonio Pereira in Brazil, and near Marmato.

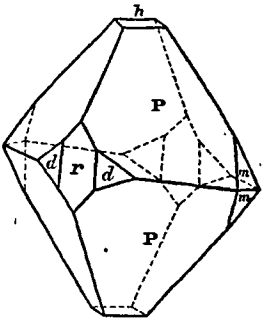


Fig. 188.

277. ARSENIOSIDERITE.—$\dot{Ca}^5\dddot{As}+3\dddot{\dot{F}e}^2\dddot{As}+11\dot{H}$.

Spherical and fibrous; friable, and leaves a mark on paper. H.=1...2; G.=3·52...3·88. Opaque; metallic pearly. Ochre-brown, becoming darker in the air; streak brownish-yellow. B.B. fuses easily, with reaction for iron and arsenic. Chem. com. 39 arsenic acid, 40·7 iron peroxide, 11·9 lime, and 8·4 water. Romanêche near Màçon in France.

278. PHARMAKOSIDERITE, Cube Ore. $\dot{Fe}^3\dddot{As}+\dddot{\dot{F}e}^3\ddot{\ddot{As}}^2+18\dot{H}$.

Tesseral and tetrahedral; usually $\infty O\infty$, with $\frac{O}{2}$, or ∞O. Cleavage, tesseral very imperfect; rather brittle. H.=2·5; G.=2·9...3. Semitransparent to translucent; adamantine or resinous. Olive to emerald green, honey-yellow, and brown; streak straw-yellow. Pyro-electric. In closed tube yields water, and becomes red. B.B. on charcoal fuses easily to a steel-gray magnetic slag; easily soluble in acids. Chem. com. 40·4 arsenic acid, 28·1 iron peroxide,

12·6 iron protoxide, and 18·9 water. Huel Gorland, Huel Unity, and Carharrak in Cornwall; Burdle Gill in Cumberland; also St Leonard in the Haute-Vienne, Lobenstein in Reuss, Schwarzenberg in Saxony, and North America.

Beudantite, said to be rhombohedral; R 92° 30'. H. above 4. Resinous; black greenish-gray streak; but probably a mixture of pharmakosiderite with sulphate of lead. Horhausen in Nassau.

Family III.—Copper Salts.

Crystallization generally rhombic and monoclinohedric. Hardness generally from 2...3·5, but a few as low as 1...2, others 4...5. Gravity 2...4, but mostly 3...4. The colours are predominantly green, and rarely blue. They are all soluble in acids, and mostly easily so. Mostly fusible B.B. and on charcoal, when moistened with hydrochloric acid, the copper is known by colouring the flame blue. With soda they are reduced to metallic copper. They are, with a few exceptions, compounds of copper with one of the common acids, and some used as ores of this metal. They occur especially in veins.

279. Dioptase, Emerald Copper.—$\dot{C}u\,\ddot{S}i + \dot{H}$.

Rhombohedric; R 126° 24'; ∞P2 (*s*). −2 R (*r*) 95° 54' (fig. 189). Cleavage, R perfect; brittle. H. = 5; G. = 3·2...3·3. Transparent or translucent; vitreous. Emerald-green, rarely verdigris or blackish green; streak green. B.B. in the outer flame becomes black, in the inner red, but is infusible; soluble, and gelatinizes in h. or s. acid, and also in ammonia. Chem. com. 38·7 silica, 50 copper protoxide, and 11·3 water. Altyntubeh in the Kirgis Steppe.

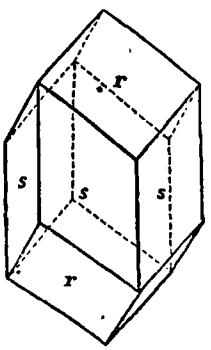


Fig. 189.

280. CHRYSOCOLLA, Copper-green.—$\dot{C}u\,\ddot{S}i + 2\dot{H}$.

Botryoidal, reniform, or investing; brittle; fracture conchoidal, and fine splintery. H. = 2...3; G. = 2·0...2·3. Translucent or semitransparent; weak resinous. Verdigris to emerald green or azure-blue; streak greenish-white. B.B. and with acids like dioptase. Chem. com. 34·83 silica, 44·94 copper protoxide, and 20·23 water. Saxony, Bavaria, Ural, Cornwall, Hungary, the Tyrol, Spain, the Harz (*Siliceous malachite*), Mexico, and Chili.

*281. AZURITE, Blue Copper.—$\dot{C}u^3\,\ddot{C}^2 + \dot{H}$.

Monoclinohedric; C = 87° 39′, ∞P (*M*) 99° 32′, −P (*k*′) 106° 14′. Crystals 0P . ∞P . ∞P∞ . −P, or *h*, *M*, *s*, *k*′, in fig. 190; also radiated and earthy. Cleavage, (P∞) (*P*) 59° 14′, rather perfect; fracture conchoidal, or splintery. H. = 3·5...4·2; G. = 3·7...3·8. Translucent or opaque; vitreous. Azure-blue, the earthy varieties (and streak) smalt-blue. B.B. on charcoal fuses and yields a grain of copper; soluble with effervescence in acids, and also in ammonia. Chem. com. 69·1 protoxide of copper, 25·7 carbonic acid, and 5·2 water. Crystals at Chessy near Lyons, Kolywan and Nischne-Tagilsk in Siberia, Moldawa in the Bannat; also Redruth in Cornwall, Alston Moor, and Wanlockhead; massive in Cornwall, Thuringia, the Harz, Hessia, and the Ural. Valued as an ore of copper.

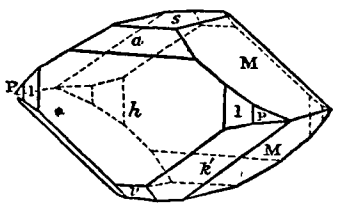


Fig. 190.

*282. MALACHITE.—$\dot{C}u^2\ddot{C} + \dot{H}$.

Monoclinohedric; C = 61° 49′, ∞P 103° 42′; crystals ∞P (*M*). ∞P∞ (*s*) . 0P (*P*), in macles (fig. 191). In general acicular, scaly, or reniform, stalactitic, and radiated fibrous. Cleavage, basal and clinodiagonal very perfect. H. = 3·5...4; G. = 3·6...4. Transparent or translucent

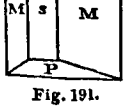


Fig. 191.

on the edges; adamantine, vitreous, silky or dull. Emerald and other shades of green; streak apple-green. B.B., and with acids, like azurite. Chem. com. 71·8 copper protoxide, 20 carbonic acid, and 8·2 water. Crystalline at Rheinbreitenbach on the Rhine, and Zellerfeld in the Harz; fibrous and compact at Chessy in France, Siberia, the Ural, Saalfeld in Thuringia, Moldawa in the Bannat, Sandlodge in Zetland, Cornwall, Wales, and Ireland, and in North America and Australia. It is a valuable ore of copper, and the finer varieties are prized for ornamental purposes.

Lime-Malachite.—Reniform, botryoidal, and radiated fibrous; brittle. H.=2·5. Silky; verdigris-green. B.B. blackens and fuses to a black slag; soluble in h. acid, leaving gelatinous gypsum. Seems a hydrous carbonate of copper and lime, with sulphate of lime and some iron. Lauterberg in the Harz. *Mysorine*, compact, blackish-brown, and soft, G.=2·62, is a mixture of a carbonate of copper with iron peroxide. Mysore in the East Indies.

283. AURICHALCITE.—$2\,\dot{C}u\,\ddot{C} + 3\,\dot{Z}n\,\dot{H}$.

Acicular. H.=2. Translucent, pearly, and verdigris-green. B.B. on charcoal in the inner flame forms a deposition of zinc oxide, and with fluxes gives reaction for copper; soluble with effervescence in h. acid. Chem. com. 29·2 copper protoxide, 44·7 zinc oxide, 16·2 carbonic acid, and 9·9 water. Loktefskoi in the Altai; Matlock in Derbyshire.

Buratite, azure-blue, and agrees with aurichalcite, but perhaps mixed with lime. Loktefskoi.

284. CHALCOPHYLLITE, Copper-mica. $\begin{cases} \dot{C}u^8\,\dddot{A}s + 23\,\dot{H}, \textit{ or} \\ \dot{C}u^6\,\dddot{A}s + 12\,\dot{H}. \end{cases}$

Rhombohedral; R 69° 48′. Crystals, $\breve{0}R$ (*o*). R (fig. 192). Cleavage, basal very perfect; sectile. H.=2; G.=2·4; ...2·6. Translucent or transparent; vitreous inclining to ada-

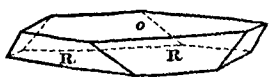


Fig. 192.

mantine; pearly on 0R. Emerald to grass or verdigris green; streak light-green. B.B. decrepitates violently, emits arsenical vapours, and fuses to a gray metallic grain; easily soluble in acids and ammonia. Chem. com. 49·6 copper protoxide, 18 arsenic acid, and 32·4 water; or 51·6 copper protoxide, 25 arsenic acid, and 23·4 water; but also 2 alumina and 1·5 phosphoric acid. Tingtang, Huel Gorland and Huel Unity Mines near Redruth; also Saida in Saxony, and Moldawa in the Bannat.

285. TIROLITE.—$(\dot{C}u^5\,\dddot{A}s + 10\,\dot{H}) + \dot{C}a\,\ddot{C}$.

Rhombic; reniform, or radiating foliated. Cleavage, basal very perfect; sectile. Thin laminæ flexible. H.= 1·5...2; G.=3...3·1. Translucent; pearly or vitreous. Verdigris-green to azure-blue; streak paler. B.B. decrepitates violently and fuses to a steel-gray bead; soluble in acids, evolving carbonic acid. Chem. com. 43·88 copper oxide, 25·01 arsenic acid, 17·46 water, and 13·65 carbonate of lime, by analysis. The carbonate of lime is perhaps accidental. Falkenstein in Tyrol, in Hungary, Reichelsdorf, Saalfeld, Piombino in Italy, in Asturia and at Linares in Spain, and Matlock in Derbyshire.

286. ERINITE.—$\dot{C}u^5\,\dddot{A}s + 2\,\dot{H}$.

Reniform and foliated; conchoidal fracture. H. = 4·5...5; G. = 4...4·1. Translucent on the edges; dull resinous. Emerald or grass green; streak similar. Chem. com. 59·9 copper protoxide, 34·7 arsenic acid, and 5·4 water. Limerick in Ireland. *Cornwallite* is similar, but dark-green, and 5 $\dot{H}$. Cornwall.

287. LIROCONITE.—$\dot{C}u^8\,\dddot{A}s + \dddot{A}l\,\dddot{A}s + 24\,\dot{H}$.

Rhombic; ∞P 119° 20′, $\bar{P}\infty$ 72° 22′ (fig. 193). Cleavage, $\bar{P}\infty$ imperfect, and $P\infty$ more so. H. =2...2·5; G.=2·8...3·0. Translucent; vitreous, or resinous on fracture. Azure-blue to verdigris-green; streak paler. In the closed tube does not decrepitate, but becomes green;

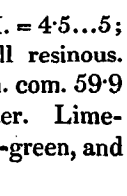


Fig. 193.

then ignites and brown. B.B. on charcoal emits arsenical vapours and fuses; soluble in acids and in ammonia. Chem. com. 36·6 copper protoxide, 11·9 alumina, 26·6 arsenic acid, and 24·9 water. Huel Unity and other mines near Redruth; also Herrengrund in Hungary and Ullersreuth in the Voightland

*288. OLIVENITE.—$\dot{Cu}^4(\ddot{As}, \ddot{P}) + \dot{H}$.

Rhombic; ∞P (*r*) 92° 30′, $\breve{P}\infty$ (*l*) 110° 50′; $\infty\bar{P}\infty$ (*n*) (fig. 194); also spherical and reniform, and columnar or fibrous. Cleavage, (*r*) and (*l*) very imperfect. H. = 3; G. = 4·1...4·4. Pellucid in all degrees; vitreous, resinous, or silky. Leek, olive, or blackish green, also yellow and brown; streak olive-green or brown. B.B. in the forceps fuses easily to a dark-brown adamantine bead covered with radiating crystals; on charcoal, detonates, emits arsenical vapours, and is reduced; soluble in acids and ammonia. Chem. com. 56.5 copper protoxide, 39·5 arsenic acid, and 4 water, but also 1 to 6 phosphoric acid.

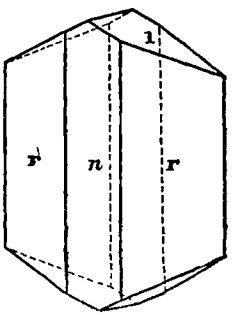


Fig. 194.

Carrarach, Tin Croft, Gwennap, and St Day in Cornwall; also Alston Moor, Thuringia, Tyrol, Siberia, Chili, and other places.

289. EUCHROITE.—$\dot{Cu}^4\ddot{As} + 7\dot{H}$.

Rhombic; ∞P (*M*) 117° 20′ $\breve{P}\infty$ (*n*) 80° 52′, with $\infty\breve{P}2$ (*l*), and 0P (*P*), (fig. 195). Cleavage *M* and *n* imperfect; rather brittle. H. = 3·5...4; G. = 3·35 ...3·45. Transparent or translucent; vitreous. Emerald or leek-green; streak verdigris-green. B.B. in forceps fuses to a greenish-brown crystallized mass; on charcoal detonates; easily soluble in nitric acid. Chem.

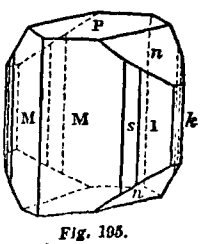


Fig. 195.

com. 47·1 copper protoxide, 34·2 arsenic acid, and 18·7 water. Libethen in Hungary.

290. KLINOCLASE, Aphanese, Abichite.—$\dot{Cu}^6 \dddot{As} + 3\,\dot{H}$.

Monoclinohedric; C = 80° 30′, ∞P 56°; also wedge-shaped and hemispherical. Cleavage, basal highly perfect. H. = 2·5...3; G. = 4·2...4·4. Translucent or opaque; vitreous; pearly on the cleavage. Dark verdigris-green inclining to sky-blue; streak bluish-green. B.B. becomes black, and is reduced; soluble in acids and ammonia. Chem. com. 62·6 copper protoxide, 30·3 arsenic acid, and 7·1 water. Cornwall and the Erzgebirge.

291. PHOSPHOROCHALCITE, Lunnite.—$\dot{Cu}^6 \dddot{P} + 3\,\dot{H}$.

Monoclinohedric; crystals (∞P2) (*f*) 38° 56′, P (*P*) 117° 49′, with 0P (*a*) and ∞P∞ (*e*) (fig. 196); usually small and indistinct, more common in spherical or reniform, and radiated fibrous masses. Cleavage, (*e*) imperfect; fracture uneven and splintery. H. = 5; G. = 4·1 ··· 4·3. Translucent, or on the edges; adamantine or resinous. Blackish, emerald, or verdigris green.

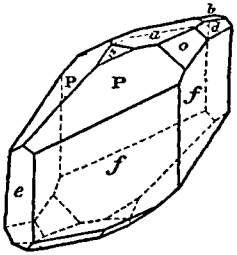


Fig. 196.

B.B. decrepitates, or blackens and fuses to a black globule; easily soluble in nitric acid or ammonia. Chem. com. 70·8 copper protoxide, 21·2 phosphoric acid, and 8 water. Rheinbreitenbach, Nischne-Tagilsk, and in Cornwall. *Dihydrite*, with about a fifth less water, *Copperdiaspore*, and *Prasin*, seem varieties.

292. THROMBOLITE.—$\dot{Cu}^3 \dddot{P}^2 + 6\,\dot{H}$.

Porodine. Fracture conchoidal; brittle. H. = 3...4; G. = 3·38...3·40. Opaque; vitreous. Emerald, leek, or dark green. B.B. colours the flame blue and then green; on charcoal fuses easily. Chem. com. 45·1 phosphoric acid, 37·8 copper protoxide, and 17·1 water. Retzbanya in Hungary.

293. LIBETHENITE.—$\dot{Cu}^4 \dddot{P} + \dot{H}$.

Rhombic; ∞P (*u*) 92° 20′, $\breve{P}\infty$ (*o*) 109° 52′, and P. (fig. 197). Cleavage, brachydiagonal and macrodiagonal imperfect. H. = 4; G. = 3·6...3·8. Translucent on the edges; resinous. Leek, olive, or blackish green; streak olive-green. B.B., and with acids, acts like the phosphorochalcite. Chem. com. 66·37 copper protoxide, 29·86 phosphoric acid, and 3·77 water. Libethen in Hungary, Tagilsk in the Ural, and Gunnislake in Cornwall.

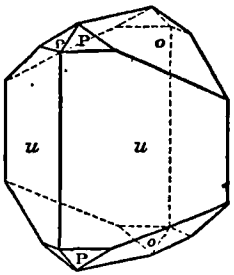


Fig. 197.

294. TAGILITE.—$\dot{Cu}^4 \dddot{P} + 3\dot{H}$.

Fungoid or botryoidal, and radiating fibrous or earthy. H. = 3; G. = 3·5. Emerald-green. Chem. com. 61·8 copper protoxide, 27·7 phosphoric acid, and 10·5 water. Nischne-Tagilsk.

295. EHLITE.—$\dot{Cu}^5 \dddot{P} + 3\dot{H}$.

Botryoidal or reniform, and radiating foliated, or compact. Cleavage in one direction perfect. H. = 1·5 ... 2; G. = 3·8 ... 4·27. Translucent on the edges; pearly on the cleavage. Verdigris-green; streak paler. B.B. breaks into small fragments thrown about violently. Chem. com. 66·8 copper protoxide, 24·1 phosphoric acid, and 9·1 water. Ehl on the Rhine, Nischne-Tagilsk, and Libethen.

296. ATACAMITE.—$Cu\,Cl + 3\,\dot{Cu}\,\dot{H}$.

Rhombic; ∞P (*M*) 112° 20′, $\breve{P}\infty$ (*P*) 105° 40′, and $\infty\breve{P}\infty$ (*h*) (fig. 198); also reniform and columnar or granular. Cleavage (*h*) perfect. H. = 3...3·5; G. = 4...4·3 (3·7, *Breit.*) Semitransparent or translu-

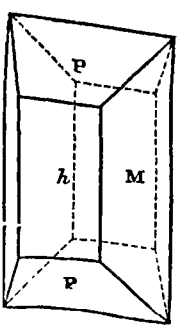


Fig. 198.

cent on the edges; vitreous. Olive, grass, or emerald green; streak apple-green. B.B. fuses, and leaves copper; easily soluble in acids. Chem. com. 55·85 copper protoxide, 14·86 copper, 16·61 chlorine, and 12·68 water; or 74·46 copper protoxide and 17·09 h. acid. Remolinos and Santa Rosa in Chili, Tarapaca in Bolivia, Schwarzenberg, and on lavas of Ætna and Vesuvius. Used as an ore of copper.

297. VOLBORTHITE.—$(\dot{Cu}, \dot{Ca})^4 \dddot{V} + \dot{H}$.

Hexagonal; small tabular crystals, $0P \cdot \infty P$, single or in groups. H.=3; G.=3·45 ... 3·89. Olive-green; streak almost yellow. B.B. on charcoal fuses easily, and forms a graphite-like slag, containing grains of copper; on platina wire, with salt of phosphorus, forms a green glass; soluble in nitric acids, and with water gives a brick-red precipitate. Chem. com. 37 to 38 vanadic acid, 39·4 to 46 copper oxide, 18·5 to 13 lime, 3·6 to 5 water. Syssersk, Nischne-Tagilsk, and Friedericksrode in Thuringia.

298. BROCHANTITE.—$\dot{Cu}\,\ddot{S} + 3\,\dot{Cu}\,\dot{H}$.

Rhombic; ∞P 104° 10′, $\breve{P}\infty$ 151° 52′, and $\infty\breve{P}\infty$; also reniform. Cleavage, brachydiagonal very perfect. H.=3·5...4; G.=3·75...3·9. Transparent or translucent; vitreous. Emerald or blackish green; streak bright-green. B.B. on charcoal fuses, leaving copper; easily soluble in acids. Chem. com. 70 copper protoxide, 18 sulphuric acid, and 12 water. Rezbanya, Katharinenburg, and Roughton Gill in Cumberland; also Krisuvig in Iceland (*Krisuvigite*), and in Siberia (*Königine*).

299. URANITE, Uran-Mica.—$(\dot{Ca} + \dddot{U})^2\,\ddot{\dddot{P}} + 8\,\dot{H}$.

Tetragonal: P 143° 2′. Crystals 0P, with ∞P or P (fig. 199). Cleavage, basal very perfect; sectile. H.=1...2; G.=3...3·2. Translucent; pearly on 0P. Siskin-green to sulphur-yellow; streak yellow. B.B. on charcoal fuses to a black semicrystalline mass; with soda forms a yellow infusible slag; in n. acid forms a yellow solution.



Fig. 199.

Chem. com. 15·5 phosphoric acid, 62·6 uranium peroxide, 6·2 lime, and 15·7 water. Johann-Georgenstadt and Eibenstock in Saxony, Autun and Limoges in France, Chesterfield in Massachusetts, and Lake Onega in Russia.

300. CHALCOLITE.—$(\dot{C}u + \dddot{U})^2 \dddot{P} + 8\,\dot{H}$.

Tetragonal, and like uranite, but brittle. H.=2...2·5; G.=3·5...3·6. Grass to emerald or verdigris green; streak apple-green. B.B. like uranite, but with soda yields a grain of copper. Chem. com. 15·2 phosphoric acid, 61·1 uranium peroxide, 8·4 copper protoxide, and 15·3 water. Johann-Georgenstadt, Eibenstock, Schneeberg, Bodenmais, near Baltimore in North America, and near Redruth and St Austle.

*301. ERYTHRINE, Cobalt-Bloom.—$\dot{C}o^3\,\dddot{A}s + 8\,\dot{H}$.

Monoclinohedric; $(\infty P\infty)$ (P) . $\infty P\infty$ (T) . $P\infty$ (M) (like fig. 186), with $M : T = 55°\ 9'$; also $\infty P3$ (k) 130° 10′, and P (l) 118° 23′ (fig. 200). Cleavage, clinodiagonal (P) very perfect; sectile; thin laminæ flexible. H.=1·5... 2·5; G.=2·9...3. Translucent; vitreous; pearly on the cleavage. Crimson or peach-blossom red. B.B. on charcoal fuses with arsenic fumes to a gray globule; colours borax blue; easily soluble in acids. Chem. com. 24 water, 38·2 arsenic acid, and 37·8 cobalt protoxide; but often with 0 to 8 lime, or the protoxides of iron 1 to 4, and nickel 0 to 9. Schneeberg, Saalfeld, Allemont, Riechelsdorf, the Pyrenees, and Modum in Norway; also Cornwall; Alston in Cumberland, at Alva in Stirlingshire, and Tyndrum in Perthshire. Used in preparing blue colours.

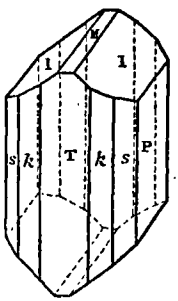


Fig. 200.

Kötigite.—White or peach-blossom red incrustations of minute crystals like erythrine, with which it agrees, except

that the cobalt is almost wholly replaced by zinc. Schneeberg.

Kobaltbeschlag, or Earthy-encrusting Cobalt, reniform or spheroidal, is a mixture of erythrine with arsenious acid.

Lavendulan.—Thin reniform lavender-blue crusts; translucent; resinous or vitreous. H.=2·5...3; G.=2·95...3·1. B.B. fuses very easily, colouring the outer flame blue. Consists of arsenic acid, protoxides of cobalt, nickel and copper, and water. Annaberg.

302. NICKELINE, Nickel-Ochre.—$\dot{N}i^3\,\ddot{\ddot{A}}s + 8\,\dot{H}$.

Monoclinohedric (?); capillary and massive; earthy, rather sectile. H.=2...2·5; G.=3...3·1. Dull or glistening. Apple-green or greenish-white; streak greenish-white and shining. B.B. on charcoal fuses with arsenical vapours; easily soluble in acids. Chem. com. 38·7 arsenic acid, 37·3 nickel protoxide, and 24 water, but with a little cobalt or iron. Andreasberg, Annaberg, Saalfeld, Riechelsdorf, Joachimsthal, and Leadhills. Used in preparing blue colours.

FAMILY IV.—LEAD-SALTS.

Crystallization predominantly rhombic and monoclinohedric in the salts of lead, but several tetragonal and hexagonal. Hardness moderate, or from 2...4·5, or generally about calc-spar. All have a high specific gravity, or from 5·3...8, —this family including all minerals without metallic lustre and aspect, with G. above 5·5. They are all soluble in nitric acid, and form coloured solutions or precipitates. They are all easily fusible, and mostly readily reduced alone, or with soda, to lead. They are mostly compounds of lead, and the cerussite is an ore of this metal. The others are not abundant, but often show fine colours. Occur chiefly in veins and mines with other ores of lead.

Lead B.B. on charcoal forms a greenish or sulphur-yellow coating round the assay. Solutions in nitric acid give, with sulphuric acid, a white precipitate, reduced B.B.; and with chromate of potassa, a yellow precipitate.

*303. CERUSSITE, Lead Spar.—$\dot{P}b\,\dot{C}$.

Rhombic; isomorphous with arragonite and nitre; ∞P (*M*) 117° 14′, $\breve{P}\infty$ 108° 13′, $2\breve{P}\infty$ (*u*) 69° 18′; also 0P, P (*t*), $\frac{1}{2}\breve{P}\infty$ (*s*), $\infty\breve{P}\infty$ (*l*), $\infty\breve{P}3$ (*e*) (figs. 201, 202).

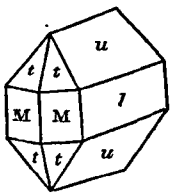


Fig. 201.

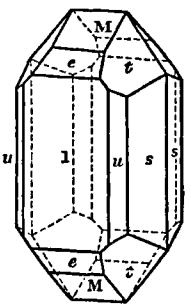


Fig. 202.

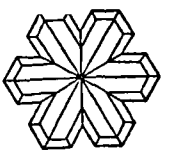


Fig. 203.

Macles are very common (fig. 203); also granular or earthy. Cleavage, ∞P and $2\breve{P}\infty$ rather distinct; fracture conchoidal; brittle and easily frangible. H. = 3...3·5; G. = 6·4...6·6 (earthy 5·4). Transparent or translucent; adamantine or resinous. Colourless and often white, but also gray, yellow, brown, black, rarely green, blue, or red; streak white. B.B. decrepitates violently, but easily fused and reduced; soluble with effervescence in nitric acid. Chem. com. 83·6 protoxide of lead and 16·4 carbonic acid. Very common at Przibram, Mies, and Bleistadt, Tarnowitz, Johann-Georgenstadt, Zellerfeld, Klausthal, Beeralston in Devonshire, St Minver's in Cornwall, Alston Moor, Keswick, Leadhills and Wanlockhead, and many other places.

304. ANGLESITE.—$\dot{P}b\,\dddot{S}$.

Rhombic; ∞P 103° 43′, $\breve{P}\infty$ 75° 35′. The crystals (fig. 204) short prismatic, or pyramidal, or tabular.

Cleavage, prismatic along ∞P and basal, neither very perfect; fracture conchoidal; very brittle. H. =3; G.=6·2...6·3. Transparent or translucent; adamantine or resinous. Colourless and white, but occasionally yellow, gray, brown, or blue; streak white. Decrepitates in candle; B.B. on charcoal fuses in the ox. flame to a milk-white bead; very difficultly soluble in acids, wholly in solution of potash. Chem. com. 73·7 lead protoxide and 26·3 sulphuric acid, in some with a little silver. Zellerfeld, Clausthal, Badenweiler, Siegen, Silesia, Linares, Southampton in Massachusetts, Parys Mine in Anglesea, St Ives in Cornwall, Derbyshire, Leadhills and Wanlockhead. Compact (*Bleiglas*), Alston Moor in Cumberland.



Fig. 204.

305. LEADHILLITE.—3 $\dot{P}b\,\ddot{C} + \dot{P}b\,\dddot{S}$.

Rhombic; P middle edge 137°, ∞P 120° 20′, $2\breve{P}\infty$ 43° 12′. Crystals, 0P . ∞P . $\infty\breve{P}\infty$ (fig. 205), mostly tabular; also macles. Cleavage, basal very perfect; slightly brittle. H.=2·5; G.=6·2...6·4 (6·0). Transparent or translucent; resinous or adamantine-pearly on 0P. Yellowish-white, inclining to gray, green, yellow, or brown. B.B. on charcoal intumesces, and becomes yellow, but again white when cold, and easily reduced; soluble with effervescence in nitric acid, leaving sulphate of lead. Chem. com. 72·6 carbonate and 27·4 sulphate of lead. Leadhills; also Grenada in Spain, and the Greek island Serpho.

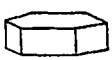


Fig. 205.

306. SUSANNITE.—3 $\dot{P}b\,\ddot{C} + \dot{P}b\,\dddot{S}$.

Rhombohedric; R 72° 30′. Cleavage, basal perfect. H. =2·5; G.=6·55. White, green, yellow, or brown. Otherwise like Leadhillite. Susannah Mine, Leadhills.

307. LANARKITE.—$\dot{P}b\,\ddot{S} + \dot{P}b\,\ddot{C}$.

Monoclinohedric; ∞P 85° 48′, P∞ 120° 45′. Cleavage, basal very perfect; sectile, thin laminæ flexible. H.=2 ...2·5; G.=6·3...7. Transparent; resinous or adamantine; on 0P pearly. Greenish or yellowish-white, inclining

to gray; streak white. B.B. on charcoal fuses to a white globule containing some metallic lead; partially soluble in nitric acid with effervescence. Chem. com. 53·15 sulphate and 46·85 carbonate of lead. Leadhills in Scotland.

308. CALEDONITE.—$3\,\dot{P}b\,\dddot{S} + 2\,\dot{P}b\,\ddot{C} + \dot{C}u\,\ddot{C}$ (?).

Rhombic; $\breve{P}\infty$ 95°, ∞P 109°. Crystals $\infty\breve{P}\infty$. $\infty\bar{P}\infty$ $\bar{P}\infty$ (fig. 206). Cleavage, $\bar{P}\infty$ brachydiagonal and macrodiagonal all imperfect. H. = 2·5...3; G. = 6·4. Transparent or translucent; resinous. Verdigris to mountain green; streak greenish-white. B.B. on charcoal easily reduced; soluble in nitric acid, leaving sulphate of lead. The solution is greenish, and shows reaction for lead and copper. Chem. com. 55·8 sulphate of lead, 38·8 carbonate of lead, and 11·4 carbonate of copper. Leadhills, Roughton Gill in Cumberland, and Rezbanya.

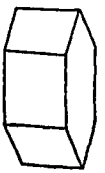


Fig. 206.

309. LINARITE.—$\dot{P}b\,\dddot{S} + \dot{C}u\,\dot{H}$.

Monoclinohedric; ∞P 61° 0′, $P\infty$ 77° 15′, $-P\infty$ 74° 25′. Crystals $\infty P\infty$. 0P, with the above or other forms; macles united by $\infty P\infty$. Cleavage, orthodiagonal very perfect, and $P\infty$ less so; fracture conchoidal. H. = 2·5...3; G. = 5·2...5·45. Translucent; adamantine. Azure-blue; streak pale-blue. Chem. com. 75·7 sulphate of lead, 19·8 copper protoxide, and 4·5 water. Wanlockhead, Leadhills, Roughton Gill, and Linares.

310. PHOSGENITE, Corneous Lead, Cerasine. $\left.\right\}\ Pb\,Cl + \dot{P}b\,\ddot{C}$.

Tetragonal; P 113° 48′. Crystals of ∞P, 0P, $\infty P\infty$, with P or $2P\infty$. Cleavage, ∞P rather perfect; fracture conchoidal. H. = 2·5 ... 3; G. = 6 ... 6·2. Transparent or translucent; resinous adamantine. White, yellow, green, or gray. B.B. fuses easily to an opaque yellow globule, citron-yellow or white and crystalline on cooling; soluble with effervescence in nitric acid. Chem. com. 51 chloride

and 49 carbonate of lead. Very rare; near Matlock in Derbyshire, and Elgin in Scotland.

311. MENDIPITE, Berzelite.—Pb Cl + 2 Ṗb.

Rhombic; but chiefly massive. Cleavage, along ∞P 102° 36′ highly perfect; fracture conchoidal or uneven. H. = 2·5...3; G. = 7·0...7·1. Translucent; adamantine-pearly on the cleavage. Yellowish-white to straw-yellow and pale-red; streak white. B.B. decrepitates, fuses easily, and becomes more yellow; easily soluble in nitric acid. Chem. com. 40 chloride and 60 protoxide of lead = 85·8 lead, and 9·8 chlorine. Churchill in the Mendip Hills, and Brilon in Westphalia.

312. MATLOCKITE.—Pb Cl + Ṗb.

Tetragonal; P 136° 17′. Crystals, 0P. P. P∞, small, thin, tabular. Cleavage, basal indistinct; fracture uneven conchoidal. H. = 2·5; G. = 7·21 (*Greg.*), 5·39 (*Ram.*) Transparent or translucent; adamantine. Yellowish or greenish. B.B. decrepitates and fuses to a grayish-yellow globule. Chem. com. 55·6 chloride of lead, and 44·4 lead oxide. Matlock, on galena.

313. COTUNNITE, Cotunnia.—Pb Cl.

Rhombic; ∞P 118° 38′, P̄∞ 126° 44′. Small acicular crystals. Transparent; adamantine. White. Easily scratched with the knife. G. = 5·238. B.B. on charcoal fuses easily, colours the flame blue, volatilizes as a white vapour, forms a white ring, and leaves a very little metallic lead; soluble in a large amount of water. Chem. com. 74 lead and 26 chlorine. Crater of Vesuvius after the eruption of 1822.

*314. PYROMORPHITE.—3 Ṗb^3 P̈ + Pb Cl.

Hexagonal; P 80° 44′. Crystals ∞P. 0P, with ∞P2, P (fig. 207) or other pyramids, occasionally thicker in the middle, or spindle-shaped; also reniform or botryoidal. Cleavage, P very imperfect, ∞P in traces; fracture conchoidal or uneven. H. = 3·5...4; G. = 6·9...7. Translu-

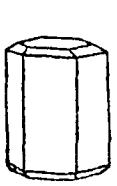


Fig. 207.

cent; resinous or partly vitreous. Colourless, but generally grass, pistacio, olive, or siskin green, and clove or hair brown. B.B. fuses easily, with a transitory ignition, to a crystalline granule; soluble in nitric acid and in solution of potash. Chem. com. 89·7 phosphate and 10·3 chloride of lead, but with 0 to 9 arseniate of lead, 0 to 11 phosphate of lime, and 0 to 1 fluoride of calcium. Przibram, Mies and Bleistadt in Bohemia, Zschopau, Clausthal, Poullaouen, Beresof, and Mexico; also Cornwall, Derbyshire, Yorkshire, Durham, Cumberland, Wicklow, and Leadhills and Wanlockhead. *Miesite*, *Polysphærite*, and *Nussierite*, from near Beaujeu, are varieties.

*315. MIMETESITE, $3\,\dot{P}b^3\,\ddot{A}s + Pb\,Cl$.

Hexagonal; P 81° 48′. Crystals, $\infty P \cdot 0P \cdot P$, or $P \cdot 0P$. Cleavage, P rather distinct, ∞P very imperfect; fracture conchoidal or uneven. H. = 3·5...4·0; G. = 7·19...7·25. Translucent. Colourless, but usually honey or wax yellow, yellowish-green, or gray. B.B. on charcoal fusible, but less easily than pyromorphite, with strong arsenious vapours. Chem. com. 90·7 arseniate and 9·3 chloride of lead; but part of the arsenic occasionally replaced by phosphoric acid. Johann-Georgenstadt, Zinnwald, Badenweiler, St Prix in France, Nertschinsk, and Zacatecas in Mexico; Huel Alfred and Huel Unity in Cornwall, Caldbeckfell in Cumberland, and Beeralston in Devonshire.

Kampylite.—Orange-yellow; G. = 6·8...6·9; Chem. com. like mimetesite, but contains phosphate of lime and chromate of lead. Alston in Cumberland and Badenweiler.

Hedyphane.—Crystalline masses with an imperfect hexagonal cleavage. G. = 5·4...5·5. Translucent; resinous adamantine. White. Chem. com. like mimetesite, but with 13 arseniate and 15·5 phosphate of lime. Langbanshytta in Sweden.

316. BLEINIERITE.—$\dot{P}b, \ddot{S}b, \dot{H}$.

Reniform, spheroidal; earthy, or encrusting. H. = 4; G.

= 3·9...4·76. Opaque; dull resinous, or earthy. Gray, brown, red, or yellow; streak grayish or yellowish-white. B.B. on charcoal reduced with antimony fumes. Chem. com. mixture of protoxide of lead (40 to 62), antimony oxides (31 to 47), and water (6 to 12); some also contain arsenic acid. Nertschinsk in Siberia, Cornwall.

317. VANADINITE.—3 $\dot{Pb}^3$ $\dddot{V}$ + Pb Cl.

Hexagonal; $\infty P . 0P$. H. = 3; G. = 6·6...7·2. Opaque; resinous. Yellow and brown; streak white. B.B. decrepitates violently, and on charcoal fuses to a globule, which emits sparks and is reduced, colouring the support yellow; in the forceps fuses, and retains its yellow colour when cold; in nitric acid forms a yellow solution. Chem. com. 89·7 vanadiate, and 10·3 chloride of lead. Zimapan in Mexico, Beresof in the Ural, and Wanlockhead.

318. DECHENITE.—$\dot{Pb}$ $\dddot{V}$.

Botryoidal or thin lamellar. H. = 3·5...4; G. = 5·81. Resinous; translucent on the edges. Red or reddish-yellow; streak yellow. B.B. fuses easily to a yellow bead; and on charcoal reduced to lead; easily soluble in nitric acid. Chem. com. 54·7 lead oxide, and 45·3 vanadic acid, but analyses gave 46 to 49 of the latter. Niederschlettenbach in Rhenish Bavaria.

Similar are—*Arœoxene;* botryoidal; red, with a brown tinge. Chem. com. vanadic acid, with 48·7 lead oxide, and 16·3 zinc oxide. Dahn on the Rhine.

Eusynchite.—Yellowish-red; opaque. B.B. melts easily to a lead-gray globule. Chem. com. 56 lead oxide, 23 vanadic acid, and 21 deutoxide of vanadium. Freiburg.

Descloizite.—$\dot{Pb}^2$ $\dddot{V}$. In small rhombic crystals. Cleavage wanting; brittle. Translucent. Olive-green to black; on fracture concentric yellow and brown zones. B.B. fuses and partially reduced. Chem. com. 54·7 lead oxide, and 22·46 vanadic acid, but also oxides of manganese, zinc, iron, and copper. La Plata.

319. WULFENITE.—$\dot{P}b\,\ddot{M}o$.

Tetragonal; P 131° 35′; 0P (*a*), $\frac{1}{4}$P (*b*), P, ∞P, and P∞ (fig. 208). Cleavage, P rather perfect, basal imperfect; fracture conchoidal to uneven; rather brittle. H. = 3; G. = 6·3...6·9. Pellucid; resinous or adamantine. Colourless, but generally yellowish-gray, wax, honey, or orange yellow. B.B. decrepitates violently; on charcoal fuses and sinks into the support, leaving lead; in con. h. acid forms a yellow solution. Chem. com. 61·5 protoxide of lead and 38·5 molybdic acid. Bleiberg and Windisch Kappel in Carinthia, Retzbanya, Badenweiler, and Zacatecas in Mexico.

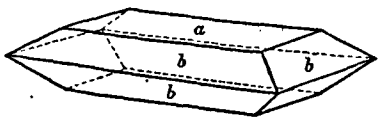


Fig. 208.

320. SCHEELETINE, Stolzit.—$\dot{P}b\,\dddot{W}$.

Tetragonal and hemihedric; P 131° 25′. Crystals, 2P . P . ∞P, spindle-shaped. Cleavage, P imperfect. H. = 3; G. = 7·9...8·1. Semitransparent or translucent; resinous. Gray, brown, yellow, or green. B.B. fuses to a dark crystalline grain; soluble in nitric acid, with a yellow precipitate. Chem. com. 51·6 tungstic acid and 48·4 protoxide of lead. Zinnwald in Bohemia and Coquimbo.

321. PLOMBGOMME.—$\dot{P}b^3\,\dddot{P} + 6\,\dddot{A}l\,\dot{H}^3$.

Reniform or stalactitic. Fracture conchoidal and splintery. H. = 4...4·5; G. = 6·3...6·4. Translucent; vitreous, inclining to resinous. Yellowish or greenish white to reddish brown, often in stripes. B.B. on charcoal becomes opaque and white, intumesces, and partially fuses; soluble in nitric acid. Chem. com. 38 protoxide of lead, 35 alumina, 8 phosphoric acid, and 19 water; but with 2 chloride of lead, a little iron peroxide and lime. Poullaouen in Brittany, and at Nussiére near Beaujeu. It much resembles gum-arabic.

322. CROCOISITE, Krokoit.—$\dot{P}b\,\ddot{C}r$.

Monoclinohedric; C = 78° 1′; ∞P 93° 44′ (*M*), −P 118° 58′

(t), (∞P2) 56° 10′ (r), (∞P∞) (g) (fig. 209). Cleavage, ∞P rather distinct; sectile. H. = 2·5...3; G. = 5·9...6·1. Translucent; adamantine. Hyacinth or aurora red; streak orange-yellow. B.B. decrepitates, blackens, and fuses on charcoal, the lower part being reduced; with borax or salt of phosphorus in the ox. flame a green, in the red. flame a gray glass; soluble in warm h. acid. Chem. com. 31·7 chromic acid, and 68·3 lead protoxide. Beresof, Mursinsk, and Nischne-Tagilsk in the Ural; Congonhas do Campo in Brazil, Rezbanya, Moldawa, and Tarnowitz. Used as a pigment, but not permanent.

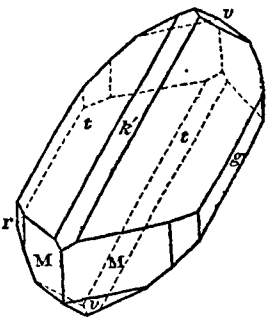


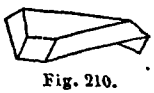
Fig. 209.

323. MELANOCHROITE, Phœnikochroite.—$\dot{Pb}^3\,\dddot{Cr}^2$.

Rhombic; dimensions unknown. Cleavage imperfect. H. = 3...3·5; G. = 5·75. Translucent on the edges; resinous or adamantine. Cochineal to hyacinth red; streak brick-red. B.B. on charcoal fuses easily to a dark crystalline mass; in the red. flame yields lead; soluble in h. acid. Chem. com. 23·6 chromic acid, and 76·4 protoxide of lead. Beresof.

324. VAUQUELINITE.—$\dot{Cu}^3\,\dddot{Cr}^2 + 2\,\dot{Pb}^3\,\dddot{Cr}^2$.

Monoclinohedric; C = 67° 15′. Crystals 0P . −P . −P∞, always macled (fig. 210), the faces of 0P forming an angle of 134° 30′; also botryoidal or reniform. H. = 2·5...3; G. 5·5...5·8. Semitranslucent or opaque; resinous. Blackish or dark olive-green; streak siskin-green. B.B. on charcoal intumesces, frothes up, and fuses to a dark-gray metallic globule surrounded by small grains of lead; in nitric acid forms a dark-green solution with a yellow residue. Chem. com. 60·87 lead protoxide, 10·80 copper protoxide,


Fig. 210.

28·33 chromic acid. Beresof, Congonhas do Campo in Brazil.

325. BISMUTHITE.

Disseminated or investing. Fracture conchoidal or uneven; very brittle. H.=4...4·5; G.=6·8...6·91. Opaque; weak vitreous. Gray, yellow, or green. B.B. decrepitates, fuses very readily, and is reduced with effervescence; in h. acid it forms a deep-yellow solution. Chem. com. essentially carbonate, with a little sulphate of bismuth. Ullersreuth near Hirschberg, Schneeberg, and Johann-Georgenstadt.

326. KERATE, Hornsilver.—Ag Cl.

Tesseral; chiefly $\infty O \infty$; small or very small; also massive. Fracture conchoidal; malleable and yields to the nail. H.=1...1·5; G.=5·3...5·4 or 5·5. Translucent; adamantine resinous; gray, occasionally bluish or greenish. B.B. fuses very easily to a gray, brown, or black bead, which in the inner flame is reduced; slightly affected by acids, and slowly soluble in caustic ammonia. Chem. com. 75 silver and 25 chlorine, but with some (0 to 6) iron peroxide. Johann-Georgenstadt, Joachimsthal, Huelgöet, Kongsberg in Norway, Spain, and Cornwall; now chiefly from Mexico and Peru. At Andreasberg in the Harz, mixed with clay (*Buttermilcherz*).

Carbonate of Silver (*Selbite*), ash-gray, massive, very soft, effervescing in nitric acid, and B.B. easily reduced, seems a mixture. Wolfach in Baden, and Real de Catorce in Mexico (*Plata azul*, a rich silver ore).

327. CALOMEL.—Hg^2 Cl.

Tetragonal; P 135° 50′. Crystals like fig. 118 above but very small; sectile. H. = 1...2; G.=6·4...6·5 (artificial 7·0). Translucent; adamantine. Grayish or yellowish-white. In the closed tube it sublimes as a white mass, and with soda yields mercury. B.B. on charcoal, when pure, wholly volatilizes; in nitric acid not soluble, in h. acid partially. Chem. com. 15 chlorine and 85 mercury. Moschellandsberg in Rhenish Bavaria, also Idria and Almaden.

328. Iodite.—Ag I.

Thin flexible plates. Malleable. H.=1...1·5; G.=5·5 ...5·7. Translucent; lustre inclining to adamantine. Pearl-gray, yellowish-gray, or greenish-yellow. B.B. on charcoal becomes red, fuses easily, colouring the flame purple-red, and leaves a grain of silver. Chem. com. 54 iodine and 46 silver. Albarradon in Zacatecas, Mexico; Arqueros in Chili, and Guadalajara in Spain.

329. Coccinite.—Hg I.

Scarlet-red, easily fusible, and subliming; said to occur at Casas Viejas in Mexico, and to be used as a pigment. Chem. com. probably 44·3 mercury and 55·7 iodine, like the artificial salt, which crystallizes in tetragonal pyramids.

330. Bromite.—Ag Br.

Tesseral; $\infty O \infty$ and O. Crystals very small; also crystalline grains. H.=1...2; G.=5·8...6. Very splendent. Olive-green or yellow, with gray tarnish; streak siskin-green. B.B. very easily fusible; scarcely affected by acids. Chem. com. 57·5 silver and 42·5 bromine. San Onofre in the district of Plateros in Mexico (*Plata verde*), and used as an ore of silver.

331. Embolite.—2 Ag Br + 3 Ag Cl.

Tesseral; $\infty O \infty$ and O. H.=1...1·5; G.=5·3...5·4 or 5·8 (*Breit.*) Resinous or adamantine. Yellow or green. Chem. com. 67 silver, 20 bromine, and 13 chlorine. Chili, Mexico, and Honduras. Ore of silver.

332. Romeite, Romeine.—$\dot{Ca}^3\,\dddot{Sb}\,\dddot{Sb}$.

Tetragonal; P 110° 30′; consequently very like an octahedron. Scratches glass. G.=4·6...4·7. Honey-yellow or hyacinth-red. B.B. fuses to a blackish slag; not soluble in acids. Chem. com. 41·3 antimonic acid, 37·3 antimony oxide, and 21·4 lime, but with 2 to 3 manganese and iron protoxide. St Marcel in Piedmont.

*333. Scheelite, Tungsten.—$\dot{Ca}\,\dddot{W}$.

Tetragonal and hemihedric; P 112° 2′; often alone. The

usual combinations are P (*P*) . 2 P∞ (*g*), (fig. 211). Cleavage, 2P∞ 129° 2′ rather perfect, along P and 0P less perfect. Fracture conchoidal and uneven. H.=4 ...4·5; G.=5·9...6·2. Translucent; vitreous, inclining to resinous or adamantine. Colourless, but gray, yellow, or brown; streak white. B.B. fuses difficultly to a translucent glass; decomposed in h. or n. acid, leaving tungstic acid; also in solution of potash. Chem. com. 80·6 tungstic acid and 19·4 lime, but with 0 to 3 silica and 0 to 1·5 iron peroxide, or rarely copper protoxide when the mineral is green. Caldbeckfell near Keswick; Pengilly, Cornwall; at Zinnwald and Schlackenwald in Bohemia; also in the gold mines of Salzburg and of Hungary; Chili and Siberia; also in the Monroe Mines in Connecticut, where used in preparing tungstic acid, a very fine yellow pigment.

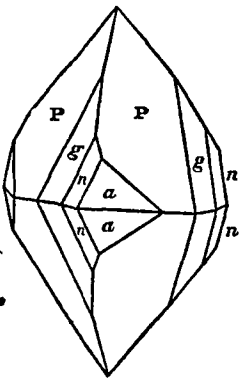


Fig. 211.

ORDER IV.

OXIDIZED ORES.

Crystallization rhombic, then tesseral or tetragonal, less frequently hexagonal or rhombohedric. Hardness generally high, or 5...7, most equal to felspar. Gravity also high, or 4...7 or 8. They are generally soluble in acids and solutions coloured. B.B. infusible, or very difficultly so. Chem. com. oxides of the metals alone or in composition. They are mostly opaque, with metallic lustre, and

of black, brown, or dark-gray colours. Occur in beds, veins, or large masses, especially in the metamorphic and igneous rocks.

Family I.—Oxidized Iron Ores.

Crystallization tesseral, rhombohedric, or rhombic. H.= 5...6·5; G.=3·4...6·5; crystalline species 4·5...5·3. Soluble in acids; solution green. B.B. infusible or very difficult, but become magnetic in the red. flame. With borax show reaction for iron. Colours black, brown, or red. Occur in beds, veins, or large masses in the older rocks, or as rock constituents.

**334. Magnetite, Magnetic Iron.—$\dot{F}e\,\ddot{\dot{F}}e$.

Tesseral; O and ∞O, also $\infty O\infty$, 2O2 and 2O. Macles common, united by O (fig. 212). Generally granular or almost compact; often also in loose grains. Cleavage, octahedral perfect, or mere traces; fracture conchoidal or uneven; brittle. H.= 5·5...6·5; G.=4·9...5·2. Opaque; lustre metallic. Iron-black, or inclining to brown or gray; highly magnetic. B.B. becomes brown and non-magnetic, and fuses with extreme difficulty; powder soluble in h. acid. Chem. com.

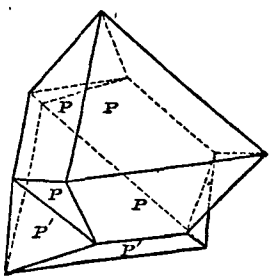


Fig. 212.

31·03 of the protoxide, and 68·77 of the peroxide of iron, or 72·4 iron and 27·6 oxygen. Crystals at Traversella in Piedmont, Greiner in Tyrol, Kraubat in Styria; large masses Arendal in Norway; Dannemora, Utoe, Norberg, Taberg in Sweden; Kurunavara and Gellivara in Lapland; Nischne-Tagilsk, Blagodat, and the Kaschkanar in the Ural; also Scotland, the Harz, Saxony, Bohemia, Silesia, Elba, and Spain; Mexico, Brazil, and North

America. Magnetite is the most important ore of iron in Norway, Sweden, and Russia.

*335. CHROMITE.—(Ḟe, Ṁg) ($\dddot{C}$r, $\dddot{A}$l).

Tesseral, only in octahedrons; generally granular. Cleavage, octahedral imperfect; fracture, imperfect conchoidal, or uneven. H.=5·5; G.=4·4...4·5. Opaque; semi-metallic or resinous. Iron or brownish-black; streak yellowish or reddish-brown. Sometimes magnetic. B.B. infusible and unchanged, but the non-magnetic in the red. flame become magnetic; in borax forms an emerald-green bead; scarcely affected by acids. Chem. com. 19 to 37 iron protoxide, 0 to 10 magnesia, 36 to 60 chrome peroxide, and 9 to 21 alumina, with 0 to 10 silica as a mixture. Saxony, Silesia, Bohemia, Styria (Kraubat), Gassin in the Var dept. in France, Röraas in Norway, Katherinenburg in the Ural, near Baltimore, Chester in Massachusetts, and Hoboken; in Scotland in great abundance in Unst and Fetlar in the Zetlands, at Portsoy in Banff, and Tyndrum. Used in the preparation of various pigments.

336. FRANKLINITE.—(Ḟe, Ż̇n, Ṁn) ($\dddot{F}$e, $\dddot{M}$n) (?).

Tesseral; O and O. ∝O; also granular. Cleavage, octahedral, but very imperfect; fracture conchoidal or uneven; brittle. H.=6...6·5; G.=5·0...5·3. Opaque; imperfect metallic lustre. Iron-black; streak dark reddish-brown. B.B. infusible, but shines brightly and gives out sparks when strongly heated. On charcoal, with soda, a deposition of zinc; soluble in h. acid with strong extrication of chlorine. Chem. com. 66 to 69 iron and 15 to 18 manganese peroxide (or in part protoxides), and 10 to 17 zinc oxide. Franklin and Sterling in New Jersey.

Dysluite, from Sterling, N. J.; dark or yellowish-brown; vitreous; G.=4·5; contains 30 per cent. alumina. *Isophane*, G.=5·01, seems also Franklinite.

**337. HÆMATITE, Specular Iron.—$\dddot{F}$e.

Rhombohedral; R 86°. Crystals rhombohedric, pris-

matic, or tabular, of R . 0R, 0R . R (fig. 213), R . $-\frac{1}{2}$R . ∞P2, R . $\frac{4}{3}$P2 . 0R, $\frac{4}{3}$P2 . R. $\frac{1}{4}$R (or *n*, *P*, *s*.), (fig. 214).

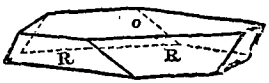


Fig. 213.

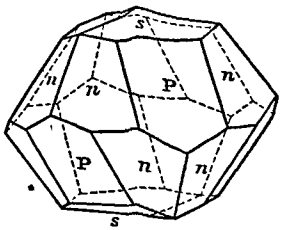


Fig. 214.

Macles with parallel axes, and mostly intersecting. Cleavage, R and 0R, but seldom distinct; fracture conchoidal or uneven; brittle. H. = 5·5...6·5; G. = 5·1...5·3. Opaque, or in very thin laminæ translucent and deep blood-red. Metallic; iron-black to steel-gray, but often tarnished, also red; streak cherry-red or reddish-brown. Usually weak magnetic. B.B. in the red. flame black and magnetic; slowly soluble in acids. Chem. com. 70·03 iron and 29·97 oxygen, but sometimes contains oxide of titanium, chrome, or silica.

Specular Iron Ore, varieties with crystalline structure and high metallic lustre, includes *micaceous iron*, thin lamellar; and *red iron froth*, finer or scaly. The *Red Hæmatite* or *red iron*, with inferior lustre, lower specific gravity (4·5...4·9), and hardness (3...5), and deeper blood-red or brownish-red colours; comprises the *fibrous red iron*, reniform, botryoidal, and stalactitic, often with an irregular concentric structure; the *compact* and *ochrey* iron ores, more earthy or minute; the *reddle* or red chalk, still more earthy, and used as a drawing material; and the *jaspery*, *columnar*, and *lenticular clay iron*, mere impure varieties.

Crystals, Elba, St Gotthardt, Framont in the Vosges, Arendal, Langbanshytta, Tilkerode in the Harz, Altenberg, Capas in Brazil, Katherinenburg and Nischne-Tagilsk. Micaceous, Zorge in the Harz, Tincroft in Cornwall, Ta-

vistock in Devonshire, Wales, Cumberland, and Birnam in Perthshire; also in Auvergne, on Vesuvius, Ætna, and Stromboli. The *Red Hæmatite*, the Harz, Ulverstone in Lancashire, St Leonards near Edinburgh, and in many other parts of Britain. A most abundant ore of iron.

Martite.—Tesseral, O, O . ∞O and O . ∞O∞. H.=6; G.=4·6...5·33. Iron-black, with reddish-brown streak. Either a pseudomorph after magnetite, or a dimorphous form of hæmatite. Brazil, Monroe in New York, Framont, and Auvergne.

338. IRITE.—(Ir̈, Ös, Fe) (Ir̈, Ös, Cr̈).

Tesseral; O; but in fine iron black scales, with strong metallic lustre, which mark paper. G.=6·506. Strongly magnetic. B.B. fused with nitre gives out the odour of osmium; insoluble in acids. Chem. com. 62·86 peroxide of iridium, 10·30 osmium protoxide, 12·50 iron protoxide, 13·7 chrome oxide, with traces of manganese. Ural, with platina.

*339. LIMONITE, Brown Iron Ore.—2 Fë + 3 Ḣ.

Fine fibrous, in spherical, reniform, and stalactitic masses; also compact and earthy. H.=5...5·5; G.=3·4 ...3·95. Opaque; lustre weak silky, glimmering, or dull. Colour brown, especially yellowish, clove, hair, and blackish-brown, also yellow and green; streak yellowish-brown. In the closed tube yields water, and the powder becomes red. B.B. in the outer flame red on ignition; in the inner flame thin splinters fuse to a black magnetic glass. Chem. com. 85·6 peroxide of iron (=60 iron), and 14·4 water; but occasionally with silica, alumina, or phosphoric acid. Harz, Thuringia, Siegen near Bonn, Naussau, Styria, Carinthia, Pyrenees, Siberia, Brazil, and the United States; in Britain in Cornwall, at Clifton near Bristol, Sandlodge in Zetland, and in many other places. A valuable ore of iron, the iron usually uniting hardness with tenacity. *Stilpnosiderite*, *Lepidokrokite*, and *Yellow ochre* seem partly this mineral, partly götheite, or mixtures.

Bog-Iron Ore is also an hydrated oxide of iron, with no definite composition, and often containing thirty to fifty per cent. of impurities. Phosphoric acid to 11 per cent. Occurs chiefly in bogs, meadows, and lakes, as in North Germany, Sweden, and Britain; especially the northern and western islands of Scotland.

*340. GOTHEITE, Pyrrhosiderite.— $\dddot{\mathrm{F}}\mathrm{e} + \dot{\mathrm{H}}$.

Rhombic; P with polar edges 121° 5′ and 126° 18′, $\infty \mathrm{P}$ (*g*) 94° 53′, $\infty \breve{\mathrm{P}}2$ (*d*) 130° 40′, $\breve{\mathrm{P}}\infty$ (*b*) 117° 30′, with $\infty \breve{\mathrm{P}}\infty$ (*M*) and P (*P*), (fig. 215); also columnar, fibrous, or scaly. Cleavage, brachydiagonal very perfect; brittle. H.=5...5·5; G.=3·8 ...4·4. Opaque, or in fine lamellæ translucent and hyacinth-red; lustre adamantine or silky. Colour yellowish, reddish, or blackish-brown; streak brownish or reddish-yellow. In the closed tube the powder yields water, and becomes reddish-brown. B.B. in the ox. flame also brown; in the red. flame black and magnetic; difficultly fusible; soluble in h. acid, often leaving a little silica. Chem. com. 90 peroxide of iron and 10 water, with silica and manganese peroxide. Foliated, Eiserfeld near Siegen. Crystals, Lostwithiel in Cornwall, and Clifton near Bristol. Capillary, Przibram, Hüttenberg in Carinthia, and Norway. Compact, Saxony, the Pyrenees, Ural, North America, and many other localities.

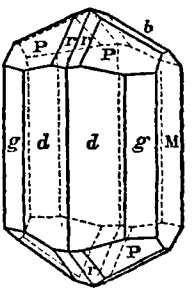


Fig. 215.

Turgite, with 94·15 peroxide of iron and 5·85 water; compact reddish-brown; G.=3·54...3·74; Turginsk in the Ural; is probably a mixture.

*341. ILMENITE, Titanitic Iron.— $\dddot{\mathrm{F}}\mathrm{e}$, $\dddot{\mathrm{T}}\mathrm{i}$.

Rhombohedric, and isomorphous with hæmatite, but sometimes tetartohedral; R 86° (85° 40′ to 86° 10′). Crystals tabular or rhombohedral, of 0R (*a*) and R, with $-\frac{1}{2}$R (*e*),

-2 R (d), and $\frac{1}{3}(\frac{1}{3}$P 2) (b'), (fig. 216.) Also in macles, granular or foliated, or in loose grains. Cleavage, basal more or less perfect, and rhombohedral R less distinct; fracture conchoidal or uneven. H. = 5 ...6; G. = 4·66...5. Opaque; semimetallic. Iron-black, often inclining to brown, rarely to steel-gray; streak generally black, but sometimes reddish-brown. Slightly or not at all magnetic. B.B. infusible alone, but with salt of phosphorus in the red. flame a red glass; soluble, but often with much difficulty in h. acid. Chem. com. peroxide of iron with 8 to 53 blue oxide of titanium. Ilmen Mountains; Gastein in Salzburg (*Kibdelophan*); Egersund in Norway; near Arendal (*Hystatit*); Menaccan in Cornwall (*Menaccanite*); Bourg d'Oisans in Dauphiné (*Crichtonite*). *Mohsite* is the same, or connected.

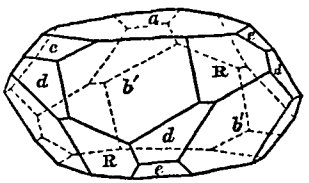


Fig. 216.

Iserine, or magnetic iron sand, in cubes, octahedrons, and dodecahedrons, generally with rounded edges or in loose grains; strongly magnetic. In chemical action and composition it resembles ilmenite, but is perhaps only magnetite mixed with peroxide of titanium. Iserweise in Bohemja, the Eifel, Auvergne, near Rome and Naples; also in Northern Germany; Cornwall, sands of the Don in Aberdeenshire, and Loch of Tristan in Zetland.

Family II.—Tin Ore.

Crystallization tetragonal, rhombic, or rarely monoclinohedric, with prismatic forms. Hardness 5·5...6·5 or 7. Gravity 3·4...4·3 in the titanium compounds, 4·6...8 in the remainder. Mostly not soluble, or very difficultly, in acids, and also B.B. very difficultly, or not fusible. Colours dark, as black, brown, or red. Lustre resinous, semimetal-

lic, or adamantine. Occur chiefly in the older crystalline strata, or in granite and syenite.

**342. CASSITERITE, Tin Ore.—$\dot{S}n$.

Tetragonal; P 87° 5′, P∞ 67° 50′. Crystals ∞P . P; ∞P (*g*) . P (*s*) . ∞P∞ (*l*), or with P∞ (*P*), (fig. 217); and also ∞P 2 (*r*), and 5 P 2 (*z*), (fig. 218). Macles very

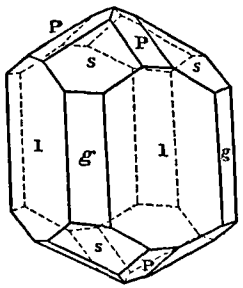


Fig. 217.

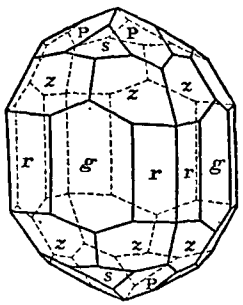


Fig. 218.

common, combined by a face of P∞, with the chief axis 112° 10′ (figs. 219, 220); also granular or fibrous (*wood tin*), or in rounded fragments and grains (*stream tin*).

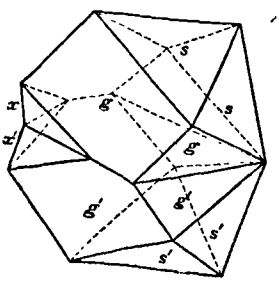


Fig. 219.

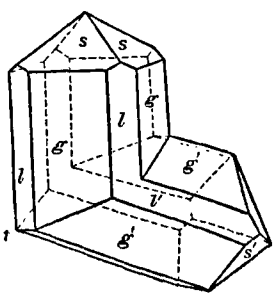


Fig. 220.

Cleavage, prismatic along ∞P and ∞P∞, rather imperfect; brittle. H.=6...7; G.=6·8...7. Translucent or opaque; adamantine or resinous. White, but usually gray, yellow, red, brown, and black; streak white, light-gray, or brown. B.B. in the forceps infusible; on charcoal, in the inner

flame, more easily with soda, reduced to tin. Not affected by acids. Chem. com. 79 tin and 21 oxygen, but often mixed with peroxide of iron or manganese, tantalic acid, or silica. Cornwall, Bohemia, Saxony, Galicia in Spain, and Portugal; also Silesia, the Haute Vienne in France, Greenland, Sweden, Russia, North and South America, Malacca, and Banca. The only ore of tin. The produce of the Cornish mines is about 100,000 cwts. annually.

Stannite.—Compact; brittle. H.=6·75; G.=3·5. Translucent only on thinnest edges; weak resinous. Yellowish white to yellow. B.B. infusible. Chem. com. 36·5 tin oxide with silica and alumina. Probably a mixture. Cornwall.

*343. WOLFRAM.—(Ḟe, Ṁn) Ẅ.

Rhombic; ∞P 101° 45′, $\frac{1}{2}\breve{P}\infty$ 123° 57′, $\breve{P}\infty$ 98° 27′. Crystals ∞P (*r*) . $\frac{1}{2}\breve{P}\infty$ (*t*) . ∞$\breve{P}\infty$ (*M*) . $\breve{P}\infty$ (*u*), (fig. 221). Macles rather common, also columnar, laminar, or coarse granular. Cleavage, brachydiagonal very perfect; macrodiagonal imperfect; fracture uneven. H.=5 ...5·5; G.=7·1...7·5. Opaque; resinous, metallic-adamantine on the cleavage. Brownish-black; streak reddish-brown to black. Sometimes weak magnetic. B.B. on charcoal fuses to a magnetic globule covered with small crystals; soluble in warm h. acid, leaving a yellow residue. Chem. com. 76 tungstic acid, 9·5 to 20 protoxide of iron, and 4 to 15 protoxide of manganese, in some with a little lime or magnesia. Altenberg, Geyer, Ehrenfriedersdorf, Schlakenwald, Zinnwald, the Harz, Cornwall near Redruth, Rona in the Hebrides; also the Ural, Ceylon, and North America.

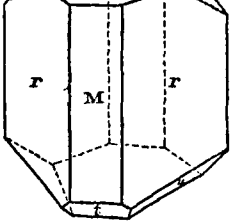


Fig. 221.

344. COLUMBITE, Niobite.—(Ḟe, Ṁn) N̈b.

Rhombic; ∞P 100° 40′, 2$\breve{P}\infty$ 59° 20′. Tabular, or

broad prismatic (fig. 222). Macles with chief axes at 59° 20′; also foliated or granular. Cleavage, macrodiagonal very distinct, brachydiagonal less so, and basal imperfect. H.=6; G.=5·4...6·4. Opaque; metallic adamantine. Brownish or iron-black; streak reddish brown or black. B.B. infusible; not affected by acids. Chem. com. 14 to 17 protoxide of iron, 3·7 to 4·8 protoxide of manganese, and 78 to 81 niobic (or columbic) acid, with a little oxide of tin or copper. Middletown and Haddam in Connecticut, and Chesterfield in Massachusetts; Rabenstein near Bodenmais, and Ilmen Mountains.

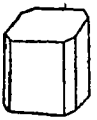


Fig. 222.

345. SAMARSKITE, Uranotantalite, Yttroilmenite.

Rhombic; isomorphous with columbite; mostly flat, somewhat polygonal grains. Fracture conchoidal; brittle. H. =5·5; G.=5·625. Opaque; strong semi-metallic. Velvet-black; streak dark reddish-brown. B.B. fuses on the edges to a black glass. In the closed tube decrepitates, yields water, incandesces, and becomes brown. Soluble in h. acid with difficulty, but wholly to a greenish fluid. Chem. com. 56 niobic acid, 15 to 16 iron protoxide, 14 to 17 uranium oxide, and 8 to 11 yttria with lime and magnesia. Ilmen Mountains in miascite.

346. TANTALITE.—(Ḟe, Ṁn) T̈a.

Rhombic; P with polar edges 126° and 112° 30′, middle 91° 42′. Cleavages all very indistinct; fracture conchoidal or uneven. H.=6...6·5; G.=7·1...8. Opaque; semimetallic, adamantine, or resinous. Iron-black; streak cinnamon or coffee brown. B.B. infusible; scarcely affected by acids. Chem. com. 7 to 14 protoxide of iron, 1 to 7 protoxide of manganese, and 67 to 84 tantalic acid, with tin oxide and lime. Kimito and Tammela in Finnland, Broddbo and Finbo near Fahlun.

Cassiterotantalite, varieties with much tin oxide, have G. =6·2...6·5, and with soda yield tin.

347. YTTROTANTALITE.—(Ẏ, Ċa, Ḟe, U̇)^3 (T̈a, Ẅ.)

Crystallization unknown; indistinct four or six sided prisms; also in grains and lamellæ. Cleavage in one direction; fracture conchoidal or uneven. Opaque, or in thin splinters translucent. Three varieties are distinguished—(*a.*) *Black Y.*, iron-black, semimetallic, and greenish-gray streak; H.=5·5; G.=5·4...5·7. (*b.*) *Dark* or *Brown Y.*, brownish-black, bright brown streak, vitreous or resinous. (*c.*) *Yellow Y.*, yellowish-gray, or brown, often striped or spotted; streak white; resinous or vitreous. H.=5; G.=5·88. B.B. infusible, but become brown or yellow; not affected by acids. Chem. com. 57 to 60 tantalic acid, 1 to 8 tungstic acid, 20 to 38 yttria, 0·5 to 6 lime, 0·5 to 6 uranium peroxide, and 0·5 to 3·5 iron peroxide. Ytterby, and near Fahlun.

348. EUXENITE.—T̈a, T̈i, Ẏ, Ċe, Ċa, Ḣ.

Monoclinohedric probably; also compact, with no trace of cleavage. Fracture imperfect conchoidal. H.=6·5; G.=4·6. Opaque; thin splinters reddish-brown translucent; metallic vitreous. Brownish-black; streak reddish-brown. B.B. infusible; not affected by acids. Chem. com. uncertain. Jölster and Arendal in Norway.

349. FERGUSONITE.—(Ẏ, Ċe, Żr)^6 T̈a.

Tetragonal and hemihedric; P 128° 28′ (fig. 223). Cleavage, traces along P; fracture imperfect conchoidal; brittle. H.=5·5...6; G.=5·8...5·9. Translucent in thin splinters; semimetallic. Brownish-black; streak pale-brown. B.B. infusible. Chem. com. 48 tantalic acid, 42 yttria, 5 cerium protoxide, 3 zirconia, with tin oxide, uranium, and iron peroxide. Cape Farewell in Greenland.

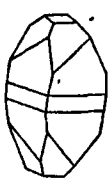


Fig. 223.

Tyrite, brown, resinous or semimetallic; H.=6·5; G.=5·13...5·36; Helle, near Arendal; is similar or identical.

Azorite, minute, greenish or yellowish white tetragonal pyramids from the Azores, seems a tantalate of lime.

*350. SPHENE, Titanite.—$\dot{C}a\ \ddot{S}i^2 + \dot{C}a\ \ddot{T}i^2$.

Monoclinohedric; C = 85° 6′; ∞P (*l*) 133° 54′, $\frac{2}{3}$P∞ (*x*) 52° 21′, P∞ (*y*) 34° 27′, 0P (*P*), (∞P∞) (*q*), (∞P3) (*M*), and ($\frac{3}{2}$P2) (*n*) 136° 6′. Crystals horizontal prismatic or tabular, or very often oblique prismatic (figs. 224, 225). Macles frequent; also granular or foliated.

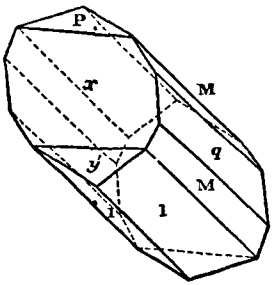


Fig. 224.

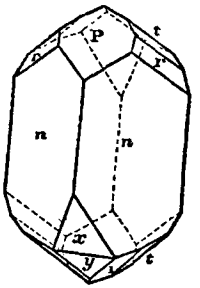


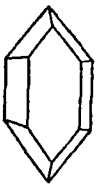
Fig. 225.

Cleavage, in many ∞P; in others (P∞) (*r*) 113° 30′, imperfect. H. = 5...5·5; G. = 3·4...3·6. Semitransparent or opaque; adamantine or often resinous. Brown, yellow, or green. B.B. fuses on the edges to a dark glass; with salt of phosphorus in the red. flame reaction for titanic acid; wholly soluble in s. acid, which forms sulphate of lime. Chem. com. 31·3 silica, 40·4 titanic acid, and 28·3 lime, with 0 to 5 iron protoxide in the brown varieties. Dauphiné near Mont Blanc, St Gotthard, Tyrol, Arendal, Sweden, Saxony, France, America, and the Ural; also Lake Laach and Vesuvius; in Scotland, in Criffell, near King's House, Ben Nevis, Strontian, Loch Ness, Aberdeenshire, Fetlar and Burra in Zetland.

Greenovite, flesh-red, from St Marcel in Piedmont, with much protoxide of manganese, is not distinct. *Schorlamite*, black shining; H. = 7...7·5; G. = 3·78...3·86; from Arkansas, is related.

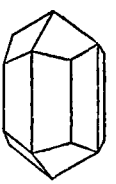
351. BROOKITE.—$\dot{T}i$.

Rhombic; P with polar edges 135° 37′ and 101° 3′, $\breve{\infty}P2$ 99° 50′ (fig. 226). Cleavage macrodiagonal. H.=5·5...6; G.=3·86...4·2. Opaque or translucent; metallic adamantine. Yellowish, reddish, or hair-brown; streak yellowish-white. B.B. infusible; with salt of phosphorus forms a brownish-yellow glass. Chem. com. titanic acid, with 1·4 to 4·5 per cent. peroxide of iron. Bourg d'Oisans, Chamouni, and near Amstäg in the Canton Uri, Miask, Magnet Cove in Arkansas (*Arkansite*); Snowdon and Tremaddoc in North Wales.


Fig. 226.

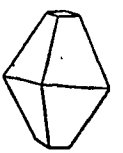
*352. RUTILE, Nigrine.—$\ddot{T}i$.

Tetragonal; P 84° 40′, P∞ 65° 35′. Crystals ∞P . ∞P∞ . P, and ∞P3 . P (fig. 227). Macles very common (like fig. 220) with chief axis at 114° 26′; also imbedded or granular. Cleavage, ∞P and ∞P∞ perfect. H.=6...6·5; G.=4·2...4·3. Translucent or opaque; metallic adamantine. Reddish-brown to red, also yellowish and black (*Nigrine*); streak yellowish-brown. B.B. unchanged alone; with borax in the ox. flame forms a greenish, in the red. flame a violet glass; not affected by acids. Chem. com. titanic acid, with 1·5 per cent. or more peroxide of iron. Alps, in Spain, St Yrieux near Limoges, Norway, the Ural, Brazil, and North America; Craig Cailleach near Killin, Ben-y-gloe and Crianlarich in Perthshire, and Burra in Zetland. Used in painting porcelain to produce a yellow colour.


Fig 227.

353. ANATASE, Octædrite.—$\ddot{T}i$.

Tetragonal; P 136° 36′. Crystals P . 0P (fig. 228), or P . $\frac{1}{3}$P. Cleavage, basal and P both perfect; brittle. H.=5·5...6; G.=3·8...3·93. Semi-transparent or opaque; metallic adamantine. Indigo-blue, almost black, red, yellow, or brown, rarely colourless; streak white. B.B. infusible; only soluble


Fig. 228.

in warm con. s. acid. Chem. com. titanic acid with a little peroxide of iron, or rarely tin oxide. The Alps, as Bourg d'Oisans, Dauphiné, Valois, and Salzburg; Hof in Bavaria, at Slidre in Norway, Ural, Minas Geraes in Brazil, and in Cornwall.

354. POLYMIGNITE.

Rhombic; P with polar edges 136° 28′ and 116° 22′, ∞P 109° 46′. Crystals long prismatic, rather broad, and vertically striated. Cleavage imperfect; fracture conchoidal. H.=6·5; G.=4·806. Opaque; semimetallic. Iron-black; streak dark-brown. B.B. infusible alone, or with soda; soluble in con. h. acid. Analysis by Berzelius—46·30 titanic acid, 14·14 zirconia, 12·20 iron peroxide, 2·70 manganese peroxide, 5·00 cerium peroxide, 11·50 yttria, 4·20 lime (=96·04). Fredriksvärn, Norway.

355. POLYKRASE.—$\dot{Z}r$, $\dot{Y}$, $\ddot{F}e$, $\dot{U}$, $\dot{C}e$, $\ddot{T}i$, $\dddot{T}a$.

Rhombic, six-sided tables, ∞P 140°. Cleavage not observable; fracture conchoidal. H.=5...6; G.=5·0...5·15. Opaque, or in very fine splinters translucent yellowish-brown. Black; streak grayish-brown. B.B. decrepitates violently, incandesces, and becomes grayish-brown, but is infusible; imperfectly soluble in warm h. acid, wholly in s. acid. Hitterö in Norway.

356. PEROWSKITE.—$\dot{C}a$ $\ddot{T}i$.

Tesseral; especially ∞O∞, also O, ∞O. Cleavage hexahedral. H.=5·5; G.=4. Opaque, or translucent on the edges; adamantine. Grayish or iron-black, or dark reddish-brown. B.B. infusible; slightly affected by acids. Chem. com. 58·9 titanic acid, and 41·1 lime, with 2 to 5 iron protoxide. Slatoust, Kaiserstuhl in Baden.

357. AESCHYNITE.— $\begin{cases} 2\,(\dot{C}e, \dot{L}a, \dot{F}e)\,(\ddot{N}b, \ddot{T}i) \\ +\ddot{C}e\,(\ddot{N}b, \ddot{T}i). \end{cases}$



Fig. 229.

Rhombic; ∞P 127° 19′, $2\breve{P}\infty$ 73° 44′. Crystals long prismatic (fig. 229). Cleavage, only in traces; fracture imperfect conchoidal. H.=5...

5·5; G.=4·9...5·1. Opaque; submetallic or resinous. Iron black or brown; streak yellowish-brown. B.B. swells and becomes yellow or brown, but is infussible; not soluble in h. acid, partially in con. s. acid. Miask in the Ural.

358. MENGITE.—$\ddot{F}e$, $\ddot{Z}r$, $\ddot{T}i$.

Rhombic; ∞P 136° 20. The crystals small, prismatic; fracture uneven. H.=5...5·5; G.=5·48. Opaque; semi-metallic. Iron-black; streak chestnut-brown. B.B. infusible, but becomes magnetic; almost wholly soluble in warm con. s. acid. Ilmen Mountains.

359. PECHURANE, Pitch-Blende.—$\dot{U}$ $\ddot{U}$.

Tesseral; O; also granular, reniform, columnar or lamellar. H.=5...6; G.=6·5 or 7·9...8. Opaque; imperfect metallic or resinous. Grayish, greenish, or brownish-black; streak greenish-black. B.B. infusible; not soluble in h. acid, but easily in warm n. acid. Chem. com. proto-peroxide of uranium, 84·78 uranium, and 15·22 oxygen, but with lead, iron, arsenic, lime, magnesia, silica, and other impurities. Some contain vanadium, others also selenium (*Gummierz*, H.=2·5...3). *Pittinerz*, olive-green streak; H.=3·0...3·5; G.=4·8...5·0; and *Coracite*, from Lake Superior, seem mixtures. Johann-Georgenstadt, Marienberg, Annaberg, Przibram, Rezbanya, and near Redruth in Cornwall. Used in porcelain-painting.

360. PLATTNERITE.—$\ddot{P}b$.

Hexagonal; ∞P . $0P$. P. Cleavage indistinct; fracture uneven; brittle. G.=9·39...9·44. Opaque; metallic adamantine. Iron-black; streak brown. Chem. com. 86·2 lead and 13·8 oxygen, with trace of sulphuric acid. Leadhills in Scotland.

Family III.—Manganese Ores.

Crystallization rhombic, tetragonal, and monoclinohedric. Crystals often prismatic. H.=1...7; G.=2·3...5. Opaque; lustre more or less perfect metallic. Colour black or brown. B.B. infusible, mostly give out much oxygen, and do *not* become magnetic; soluble in hydrochloric acid, with fumes of chlorine. The solution, saturated with carbonate of lime and filtered, gives, with chloride of lime, a copious dark-brown precipitate which acts like manganese oxide. Occur chiefly in veins in the older rocks, often along with barytes.

*361. Pyrolusite.—$\ddot{M}n$.

Rhombic; ∞P 93° 40′; $\breve{P}\infty$ 140°. Crystals short, prismatic, or pointed (fig. 230); generally massive or reniform, and radiating, fibrous, earthy, or compact. Cleavage, ∞P, also macro- and brachy-diagonal; rather brittle or friable. H.=2...2·5; G.=4·7...5. Opaque; semimetallic or silky. Dark steel-gray, bluish, or iron-black; streak black and soiling. B.B. infusible, loses oxygen, and becomes brown; soluble in h. acid, with large evolution of chlorine. Chem. com. 63·6 manganese and 36·4 oxygen. Ilmenau, Ihlefeld, Goslar, Johann-Georgenstadt; also France, Hungary, Brazil, Cornwall and Devon. Used for producing oxygen, chlorine, and chloride of lime, removing the brown and green tints in glass, in painting glass and enamel-work, and for glazing and colouring pottery.

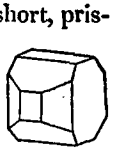


Fig. 230.

Varvacite.—With 5 water, pseudomorphs after calc-spar; also crystals with $\infty P = 99°\ 36'$, or columnar, and fibrous. G.=4·5...4·6. Semimetallic. Iron-black to steel-gray; streak black. Warwickshire.

362. Polianite.—$\ddot{M}n$.

Rhombic; ∞P 92° 52′, $\breve{P}\infty$ 118°. Crystals generally

short, prismatic, and vertically striated; also granular. Cleavage, brachydiagonal perfect. H.=6·5...7; G.=4·84...4·88. Opaque; weak metallic. Light steel-gray. B.B. acts like pure hyperoxide of manganese. Chem. com. identical with pyrolusite, which seems thus a less hard variety or product of decomposition. Platten, Schneeberg, and Johann-Georgenstadt.

*363. MANGANITE.—$\dot{\ddot{M}}$n + $\dot{H}$.

Rhombic, sometimes hemihedric; ∞P (*M*) 99° 40′, ∞$\breve{P}$2 (*l*) 118° 42′, $\bar{P}\infty$ (*c*) 114° 19′; also $\bar{P}$3 (*g*), ∞$\breve{P}$2 (*r*), 2$\bar{P}$ (*m*), and 2$\breve{P}$2 (*n*), (fig. 231). Crystals prismatic, vertically striated, and in bundles; also columnar or fibrous, rarely granular. Cleavage, brachydiagonal very perfect, basal and ∞P less perfect; rather brittle. H.=3·5...4; G.=4·3...4·4. Opaque; imperfect metallic. Dark steel-gray to iron-black, or often brownish-black and tarnished; streak brown. B.B. infusible; soluble in warm con. h. acid. Chem. com. 89·9 manganese peroxide and 10·1 water. Ihlefeld, in the Harz, Thuringia, Christiansand in Norway, Undenaes in Sweden, Nova Scotia, and Danestown near Aberdeen.

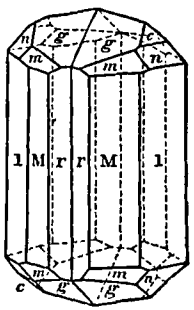


Fig. 231.

364. HAUSMANNITE.—$\dot{M}$n + $\dot{\ddot{M}}$n, *or* $\dot{M}n^2\ddot{M}n$.

Tetragonal; P 117° 54′, P∞ 99° 11′. Crystals P or P.. $\frac{1}{3}$P. Macles common (fig. 77); also granular. Cleavage, basal rather perfect, less distinct P and P∞; fracture uneven. H.=5·5; G.=4·7...4·8. Opaque; strong metallic. Iron-black; streak brown. B.B. like peroxide of manganese; soluble in h. acid, with escape of chlorine; powder colours con. s. acid bright-red in a short time. Chem. com. 31 protoxide and 69 peroxide of manganese, or 72·4 manganese and 27·6 oxygen. Ihlefeld, and near Ilmenau.

365. BRAUNITE.—$\dddot{M}n$.

Tetragonal; P 108° 39′; hence almost an octahedron. Crystals P and P . 0P. Cleavage, P rather perfect; brittle. H.=6...6·5; G.=4·818. Opaque; imperfect metallic. Colour and streak dark brownish-black. B.B., and with acids like manganite. Chem. com. 70 manganese and 30 oxygen. Elgersburg, Oehrenstock, Ihlefeld, and St Marcel (*Marceline*).

366. PSILOMELANE.—(Mn, Ba, K, Cu) $\ddot{M}n + \dot{H}$.

Massive, botryoidal, or stalactitic. Fracture conchoidal or uneven. H.=5·5...6; G.=4·1...4·2. Opaque; dull or glimmering. Iron-black or bluish-black; streak brownish-black and glistening. B.B. infusible. Chem. com. 4·7 to 11 protoxide of manganese, 80 hyperoxide (but 20 to 50 mixed), 6 to 16 baryta, 2 to 5 potash, 0 to 1 copper, and 0·5 cobalt protoxide; and thus a mixture. Schneeberg, Ilmenau, France, Vermont, Cornwall, and Devon.

367. CREDNERITE.—$\dot{C}u^3\,\ddot{M}n^2$.

Monoclinohedric; granular, foliated. Cleavage, basal very distinct, prismatic imperfect. H.=4·5...5; G.=4·9 ...5·05. Opaque; metallic. Iron-black; streak brownish-black. B.B. very thin foliæ scarce fusible on the edges; with salt of phosphorus in the inner flame forms a glass, first green, then copper-red; in h. acid it forms a green solution. Chem. com. 42·85 copper protoxide and 57·15 peroxide of manganese. Friedrichsrode in Thuringia.

368. CUPREOUS MANGANESE.—(Mn, Cu) $\ddot{M}n^2 + 2\dot{H}$.

Amorphous; botryoidal, stalactitic, or earthy. Rather brittle or friable. H.=3·5 or less; G.=3·1...3·2. Opaque; vitreous. Black, inclining to brown or blue; streak similar. Gives off much water in the closed tube. B.B. fusible, and yields copper. Contains 14 to 17 copper protoxide, 1·6 baryta, 2·5 lime, 0·2 to 0·6 protoxide of cobalt and nickel, 15 to 17 water, and other substances; thus scarcely a true species. Silesia, Saxony, the Harz, and Cornwall.

Black copper, with 28 iron peroxide, 29·5 water, is similar. Harz.

369. EARTHY COBALT.—(Ċo, Ċu) M̈n² + 4 Ḣ.

Amorphous; reniform, sectile. H. = 1...1·5; G. = 2·1... 2·2. Opaque; dull. Bluish or brownish-black; streak black, shining, and leaves a mark. B.B. infusible. Contains about 20 cobalt protoxide, 4·5 copper protoxide, and 21 water. Saalfeld, Glücksbrun, Riechelsdorf, and Alderley Edge in Cheshire. *Horn-cobalt*, Siegen, is a mixture with quartz.

*370. WAD.—Ṁn (Ċa, Ḃa, K̇) M̈n² + 3 Ḣ.

Massive; reniform, stalactitic, or froth-like; also scaly, earthy, or compact. Very soft and sectile (rarely brittle, and H. = 3); G. = 2·3...3·7; or porous, and swims on water. Opaque; semimetallic, and shining or dull. Colour and streak brown or black. B.B. like peroxide of manganese; soluble in h. acid. Chem. com. very uncertain. Saxony, Harz, France, Devonshire, and Cornwall. *Groroilite* is a variety, and *Newkirkite* related.

OCHRES.

The following substances, chiefly products of decomposition, and all compact, earthy, or disseminated, and scarcely true mineral species, may be described here:—

371. COBALT-OCHRE, Earthy Cobalt.—F̈e, Ä̈s, Ċo, Ċa, Ḣ.

H. = 1...2; G. = 2...2·65. Yellowish-gray or brown to liver-brown; streak brown or yellowish-gray and shining. In the closed tube yields water. B.B. emits odour of arsenic, and fuses to a black magnetic slag. Saalfeld, Riechelsdorf, Dauphiné, and other localities.

372. MOLYBDENA-OCHRE.—M̈o.

Opaque; dull. Straw, sulphur, or orange yellow. B.B. fuses and smokes; soluble in h. acid. Sweden, Norway, the Tyrol, and on Corybuy near Loch Creran in Scotland

*373. BISMUTH-OCHRE.—$\dddot{B}i$.

Very soft and friable. G.=4·36...4·7. Opaque; dull, or glimmering. Straw-yellow to light-gray or green. B.B. fusible and easily reduced; easily soluble in nitric acid. Schneeberg, Siberia, and St Agnes in Cornwall.

374. ANTIMONY-OCHRE.—$\dddot{S}b$, $\dot{H}$.

Soft and friable. G.=3·7...3·8. Opaque; dull or glimmering, with glistening streak. Yellow, yellowish-gray, or white. B.B. easily reduced. Harz, Hungary, Saxony, France, Spain, and Padstow in England.

375. STIBLITE.—$\ddot{\dddot{S}}b$, $\dot{H}$.

H.=5·5; G.=5·28. Resinous or dull. Yellowish-white or yellow. B.B. not reduced alone, but easily with soda. Chem. com. 75 antimony, 20·5 oxygen, and 5·5 water Kremnitz, Felsöbanya, and Mexico.

376. TUNGSTEN-OCHRE.—$\dddot{W}$.

Soft. Opaque; dull. Yellow or yellowish-green. Soluble in caustic ammonia. Huntington in North America.

377. URANIUM-OCHRE.—$\ddot{U}$, $\dot{H}$.

Sectile, soft, and friable. Opaque; dull. Straw, sulphur, or orange yellow. In the closed tube yields water, and becomes red. B.B. in the red. flame becomes green, but does not fuse; easily soluble in acids. Joachimsthal, Johann-Georgenstadt, and St Symphorien in France.

378. MINIUM (Native).—$\ddot{P}b + 2\,\dot{P}b$.

H.=2...3; G.=4·6. Opaque, dull or weak resinous. Aurora-red; streak orange-yellow. B.B. fuses easily, and reduced; in h. acid loses its colour, and changed into chloride of lead. Chem. com. 90·7 lead and 9·3 oxygen. Schlangenberg in Siberia, Badenweiler, Anglesea, Grassington Moor and Weirdale in Yorkshire.

379. LEAD-OCHRE.—$\dot{P}b$.

G.=8·0. Opaque; dull. Sulphur or lemon yellow. Popocatepetl in Mexico.

380. CHROME-OCHRE.—$\dddot{C}r$.

Opaque, or translucent on the edges; dull. Grass-green to siskin or yellowish green. B.B. infusible; soluble to a green fluid in solution of potash. Unst in Zetland, Creuzat in France, and Sweden. *Wolchonskoite*, emerald or blackish green, from Okhansk in Perm, is similar.

381. TELLURITE.—$\ddot{T}e$.

Spherical, and radiated fibrous. Yellowish or grayish white. Siebenbürg.

FAMILY IV.—THE RED COPPER ORES.

Tesseral and hexagonal. H.=3·5...4·5; G.=5·4...6. Translucent; metallic. Red or dark-gray. Soluble in acids, and B.B. fusible, except zincite. Are oxides of copper or zinc.

*382. CUPRITE, Red Copper Ore.—$\dot{C}u$.

Tesseral; O, ∞O, and ∞O∞; granular or compact. Cleavage, octahedral rather perfect; brittle. H.=3·5...4; G.=5·7...6. Translucent or opaque; metallic-adamantine. Cochineal to brick red, with a lead-gray tarnish; or crimson in transmitted light; streak brownish-red. B.B. on charcoal becomes black, fuses, and reduced; soluble in acids and ammonia. Chem. com. 88·9 copper and 11·1 oxygen. Siberia, the Bannat, Chessy near Lyons, Linares in Spain, and in the Huel Gorland, Huel Muttrel, Carvath, and United Mines in Cornwall.

383. CHALCOTRICHITE.

Rhombic or tesseral; in fine capillary crystals (prisms or cubes). Cochineal and crimson red. In other characters like cuprite. Rheinbreitenbach, Moldawa, and Huel Gorland, Carharrack, and St Day, in Cornwall.

Tile-ore.—Reddish-brown, or brick-red and earthy. Chem. com. suboxide of copper, mixed with much peroxide of iron and other substances. Bannat, Thuringia, Cornwall, and Shropshire.

384. TENORITE.—$\dot{C}u$.

Hexagonal, in thin tables; also fine scaly or earthy. Translucent and brown; metallic. Dark steel-gray or black. On lava, Vesuvius.

385. ZINCITE, Red Zinc.—$\dot{Z}n$.

Hexagonal; granular or foliated. Cleavage, basal and ∞P very perfect. H.=4···4·5; G.=5·4...5·5. Transucent on the edges; adamantine. Blood or hyacinth red; streak orange-yellow. B.B. infusible, but phosphoresces. Chem. com. 80·26 zinc and 19·74 oxygen, but with 3 to 12 manganese peroxide. Franklin and Sterling in New Jersey. Ore of zinc.

FAMILY V.—THE WHITE ANTIMONY ORES.

386. VALENTINITE, White Antimony.—$\dddot{S}b$.

Rhombic; ∞P 137°, $\breve{P}\infty$ 70½°. Crystals $\infty\breve{P}\infty \cdot \infty P \cdot \breve{P}\infty$ (fig. 232); broad prismatic, or long tabular; also granular, columnar, or foliated. Cleavage, ∞P very perfect, brachydiagonal imperfect. H.=2·5...3; G.=5·5 ...5·6. Translucent; adamantine or pearly. Yellowish and grayish-white, brown, gray, and rarely peach-blossom red; streak white. B.B. becomes yellow, and fuses (in the flame of a candle) to a white mass. In the closed tube wholly sublimes; on charcoal forms a thick white coating; easily soluble in h. acid; the solution yields with water a white precipitate. Chem. com. 83·6 antimony and 16·4 oxygen. Przibram, Braunsdorf in Saxony, Harz, Hungary, Allemont in Dauphiné, and Siberia.

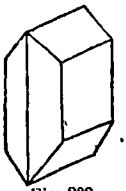


Fig. 232.

387. SENARMONTITE.—$\dddot{S}b$.

Tesseral; O; also massive. Cleavage, O imperfect. G.=5·22...5·30. Transparent to translucent; brilliant resinous or adamantine. White or gray. B.B. and chem.

com. like valentinite. Sensa near Constantine in Algeria, Perneck in Hungary.

388. CERVANTITE.—$\dot{\dot{S}}\dot{b}\ \dot{\dot{S}}\dot{b}$.

Acicular or incrusting. G.=4·1. Resinous. Yellow or white. B.B. infusible, but reduced on charcoal; soluble in h. acid. Chem. com. 79·5 antimony, 20·5 oxygen. Cervantes in Spain, Auvergne, Hungary, and Pereta in Tuscany.

389. ARSENITE.—$\dot{A}s$.

Tesseral; O; usually capillary, flaky, or pulverulent. Cleavage octahedral. H.=1·5 (3, *Breit.*); G.=3·6...3·7. Translucent; vitreous. Colourless and white. Taste sweetish astringent; highly poisonous. B.B. in closed tube sublimes in small octahedrons; on charcoal volatilizes with strong smell of garlic. Chem. com. arsenious acid, with 75·76 arsenic and 24·24 oxygen. Andreasberg, Joachimsthal, Kapnik, Alsace, and Pyrenees.

ORDER V.

NATIVE METALS.

Form only one family. Crystallization either tesseral in regular octahedrons, as gold, silver, copper, and lead; or rhombohedric, with R=86° to 88°, as antimony, arsenic, tellurium, and bismuth (tin is tetragonal). H. ranges from 1·5 in lead to 6...7 in iridium; G. from 5·7 in arsenic to 23 in iridium. Some (platina, palladium, iridium, and iron) are infusible; gold and the others easily fusible; antimony, arsenic, and tellurium, burn and fume.

They are all opaque, metallic lustre, and pure metallic colours (not lead-gray nor black); streak similar and shining. Are simple metals or their combinations.

*390. PLATINA.—Pt, Fe.

Tesseral; very rarely in small cubes, commonly in minute, flat, or obtuse grains and roundish lumps. Cleavage wanting; fracture hackly; malleable and ductile. H. =4...5; G.=17...19 (hammered 21·23). Steel-gray, inclining to silver-white. Sometimes slightly magnetic. Very difficultly or not fusible; in nitrochloric acid forms a red coloured solution. Chem. com. platina, but generally alloyed with 4 to 13 iron, 1 to 5 iridium, and many other metals. Found in diluvial deposits in Columbia, Brazil, and St Domingo; in the Ural; also in California, Canada, Borneo, the Harz, and France. The largest mass from South America weighs 1 lb. 9⅛ oz.; from the Ural, 18⅛ lb. English avoirdupois. Its hardness, infusibility, power of resisting acids, and other properties, render platina a very important material for chemical, mathematical, and philosophical instruments. In Russia also used for money.

391. PALADIUM.—Pd.

Tesseral; in very minute octahedrons; mostly small grains or scales. Malleable. H.=4·5...5; G.=11·8...12·2. Light steel-gray or silvery-white. B.B. infusible; in nitric acid forms slowly a brownish-red solution. Chem. com. palladium, alloyed with platinum and iridium. Brazil, in gold sands; Tilkerode in the Harz, in very small, brilliant, hexagonal tables;—hence rhombohedric and dimorphous. Used for astronomical and other instruments.

392. OSMIUM-IRIDIUM.—Ir, Os.

Hexagonal; P 124°; or rhombohedric, R 84° 52′, 0P . P . ∞P (fig. 233), more common in small flat grains. Cleavage, basal rather perfect. Slightly malleable. Not affected by acids.

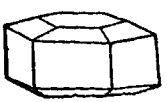


Fig 233.

(*a.*) *Osmiridium.*—Tin-white. H.=7; G.=19·38...19·47. B.B. not altered. Analysis, 46·77 iridium, 49·34 osmium, 3·15 rhodium, 0·74 iron, and trace of palladium. Katherinenburgh.

(*b.*) *Iridosmium.*—Lead-gray. H.=7; G.=21·118 (*G. Rose*). B.B. on charcoal becomes black, with a very strong odour of osmium; in the flame of a spirit-lamp shines brightly and colours it yellowish-red. In one variety Berzelius found 25 iridium and 75 osmium, or Ir Os^3; in another, 20 iridium and 80 osmium, or Ir Os^4. Nischne-Tagilsk, Ural, Brazil, and Borneo.

393. IRIDIUM, Platin-iridium.—Ir, Pt.

Tesseral; $\infty O\infty$. O; also small rounded grains. Cleavage, traces; slightly malleable. H.=6...7; G.=21·57...23·46. Silver-white, inclining to yellow on the surface. B.B. unalterable; insoluble in acids, even the nitrochloric. Chem. com., by Svanberg's analysis, 76·80 iridium, 19·64 platina, 0·89 palladium, and 1·78 copper. Nischne-Taglisk and Newjansk. Used in porcelain-painting.

*394. GOLD.—Au.

Tesseral; O, $\infty O\infty$, ∞O, 3O3, $\infty O2$, and other forms. Crystals small, often elongated, deformed, and indistinct; also capillary, wire-like, arborescent, and in plates and grains. Remarkably ductile and malleable. H.=2·5...3; G.=17·0...19·4. Gold-yellow to brass or bronze yellow. B.B. easily fusible; soluble in aqua regia, often with a precipitate of chloride of silver. The solution is yellow, and colours the skin deep purple-red. Chem. com. gold with silver to 38 per cent., and copper and iron under 1 per cent. In beds, veins, and alluvial deposits in many parts of the world,—the Ural, Brazil, California, Australia; in the sand of many rivers, as Rhine and Tagus; in Britain in many of the Cornish stream-works; in mineral lodes near Dolgelly, North Wales; in Scotland at Leadhills, Tyndrum, and Glen Coich, Perthshire; and in Ireland in Wicklow.

*395. SILVER.—Ag.

Tesseral; cubes and octahedrons; also ∞O, 3O3, and $\infty O2$. Crystals small and often misshapen; also capillary, filiform, arborescent, or tooth-like, and in leaves, plates, or crusts. Malleable and ductile. H.=2·5...3; G.=10·1

...11·1. Silver-white, but often tarnished yellow, red, brown, or black. B.B. easily fusible; easily soluble in nitric acid; the solution colours the skin black. Chem. com. silver, often with copper, iron, gold (28 per cent.), platina, antimony, and arsenic. Chiefly in veins, as at Andreasberg, Freiberg, Johann-Georgenstadt, and Kongsberg in Norway; Mexico and Peru; St Mewan, St Stephens, Huel Mexico, and Herland in Cornwall; and at Alva in Stirlingshire.

396. ANTIMONY-SILVER, Discrasite.—Ag^4 Sb.

Rhombic; P with polar edges 132° 42′ and 92°, ∞P 120° nearly. Crystals short prismatic or thick tabular, and vertically striated; macles united by a face of ∞P; often in stellar groups (fig. 234); also massive or granular. Cleavage, basal and $\breve{P}\infty$ distinct; ∞P imperfect; rather brittle, and slightly malleable. H.=3·5; G.=9·4...9·8. Silver-white to tin-white, with a yellow or blackish tarnish. B.B. fuses easily; fumes, staining the charcoal white, and leaves a grain of silver; soluble in nitric acid. Chem. com. 78 silver and 22 antimony. Andreasberg, Allemont in Dauphiné, Spain, and Arqueras in Coquimbo. A valuable ore of silver.

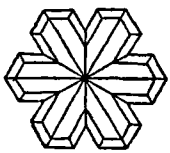


Fig. 234.

397. MERCURY, Native Quicksilver.—Hg.

Fluid; but at −40° congeals, and forms tesseral crystals. G.=13·545 fluid, 15·612 solid. Bright metallic; tin-white. B.B. wholly volatile, or leaves a little silver. Chem. com. mercury, sometimes with a little silver. Idria, Almaden, Wolfstein, and Mörsfeld on the Rhine, the Harz, Peru, China, and California.

398. AMALGAM.—Ag Hg^2, and Ag Hg^3.

Tesseral; ∞O, with 2O2, O, ∞O∞, $3O\frac{3}{2}$, and ∞O3; also compact, or in crusts and plates. Cleavage, traces along ∞O; rather brittle. H.=3...3·5; G.=13·7...14·1. Silver-white, and leaves the same colour on copper. In the closed

tube yields mercury and leaves silver; easily soluble in nitric acid. Chem. com. 35 and 26·5 per cent. silver. Mörsfeld and Moschellandsberg in Rhenish Bavaria, Hungary, Sala, Allemont, and Almaden. *Arquerite* in small octahedrons and arborescent; ductile and malleable. H.=2 ...2·5; G.=10·8. Chem. com. 86·5 silver. Forms the chief ore in the rich silver mines of Arqueros near Coquimbo.

399. ANTIMONY.—Sb.

Rhombohedric; R 87° 35′, but very rarely crystallized, generally massive or spherical, and botryoidal. Cleavage, basal highly perfect; R perfect, and −2R imperfect; rather brittle and sectile. H.=3...3·5; G.=6·6...6·8. Tin-white, with a grayish or yellowish tarnish. B.B. easily fusible; on charcoal burns with a weak flame; volatilizes and forms a white deposit. Chem. com. antimony, with a little silver, iron, or arsenic. Andreasberg, Przibram, Sala, and Allemont.

400. ARSENIC-ANTIMONY.—$Sb\,As^3$.

Rhombohedric; spherical or reniform. H.=3·5; G.=6·1...6·2. Tin-white to lead-gray, and tarnished with brownish-black. B.B. gives out a strong smell of arsenic. Chem. com. 35·2 antimony and 64·8 arsenic; but the two metals are isomorphous, and form indefinite compounds. Allemont; also Przibram, Schladming, and Andreasberg.

401. ARSENIC.—As.

Rhombohedric; R 85° 26′; 0R, R, $-\frac{1}{2}$R (fig. 235); usually fine granular, rarely columnar, botryoidal, or reniform. Cleavage, basal perfect, R and $-\frac{1}{2}$R imperfect; brittle. H.=3·5; G.=5·7...5·8. Whitish lead-gray, but in a few hours acquires a grayish-black tarnish.

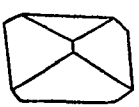


Fig. 235.

When broken or heated gives out arsenical odours. B.B. easily fusible, but on charcoal gives off dense white vapours, and may be wholly volatilized without fusing. Chem. com. arsenic, with some antimony, and traces of iron, silver, or gold. Andreasberg, Annaberg, Schneeberg, Marienberg, Freiberg, Joachimsthal, Kapnik, Orawitza, Allemont,

St Marie aux Mines in Alsace, and Königsberg; Tyndrum in Perthshire; also the Altai, North America, and Chili.

Arsenic-silver is a compound with silver; Kongsberg. *Arsenic-glance*, with 3 bismuth; H.=2; G.=5·36...5·39; dark lead-gray; takes fire at the flame of a candle, and burns; Marienberg. Arsenic is used in various pharmaceutical preparations and metallurgic processes.

402. TELLURIUM.—Te.

Rhombohedric; R 86° 57′; ∞R . 0R . R . −R; usually massive, and fine granular. Cleavage, ∞R perfect, basal imperfect; slightly sectile. H.=2...2·5; G.=6·1...6·3. Tin-white. B.B. very easily fusible; burns with a greenish flame and much smoke, which forms a white ring with a reddish margin on charcoal. In con. s. acid forms a bluish-red solution. Chem. com. tellurium, with a little gold or iron. Facebay in Siebenburg.

403. LEAD.—Pb.

Tesseral, but only capillary, filiform, or in thin plates. Ductile and malleable. H.=1·5; G.=11·3...11·4. Bluish-gray with a blackish tarnish. B.B. very easily fusible; on charcoal volatilizes and forms a sulphur-yellow coating; soluble in nitric acid. In lava on Madeira; also near Bristol and Kenmare in Ireland; in meteoric iron from Chili.

404. TIN.—Sn.

This metal has not certainly been found native, though quoted from Cornwall. The fused metal crystallizes in regular octahedrons. That formed by galvanic action is described as tetragonal, with P 57° 13′..

*405. BISMUTH.—Bi.

Rhombohedric; R 87° 40′. Crystals R . 0R, but often misshapen, also aborescent or reticulated; often massive and granular. Cleavage, −2 R 69° 28′, and basal perfect. Not malleable; very sectile. H.=2·5; G.=9·6...9·8. Reddish silver-white, often with a yellow, red, brown, or parti-colour tarnish. B.B. very easily fusible, even in the flame of a candle. On charcoal volatilizes, leaving a citron-

yellow coating. Soluble in nitric acid. Chem. com. bismuth; sometimes with a little arsenic. Schneeberg, Annaberg, Marienberg, Joachimsthal; Bieber in Hanau; Wittichen; also Modum and Fahlun; near Redruth in Cornwall, Carrick-Fell in Cumberland, and Alva in Stirlingshire.

*406. COPPER.—Cu.

Tesseral; O, $\infty O\infty$, ∞O, $\infty O2$. Crystals small, and generally irregular and deformed. Macles united by a face of O. Often filiform and arborescent, or in plates and laminæ. Malleable and ductile. H.=2·5...3; G.=8·5... 8·9. Copper-red, with yellow or brown tarnish. B.B. rather easily fusible, colouring the flame green; readily soluble in nitric acid. In large masses (200 tons) near Lake Superior, with native silver. Cornwall, near Redruth and the Lizard; Yell in Zetland, Chessy near Lyons, the Bannat, and Hungary; Faroe Islands, Siberia, China, Canada, Mexico, Brazil, and Chili.

*407. IRON.—Fe.

Tesseral; chiefly the octahedron. Cleavage hexahedral, but often mere traces; fracture hackly; malleable and ductile. H.=4·5; G.=7...7·8. Steel-gray or iron-black, often with a blackish tarnish. Very magnetic. B.B. infusible, or only in thin plates with a strong heat; soluble in h. acid. Two varieties are distinguished.

(*a.*) *Telluric Iron.*—In grains and plates, or disseminated. Almost pure iron, or contains carbon, graphite, lead, or copper, but not nickel. Said to occur at Gross Camsdorff, Oule in Dauphiné; in the gold sands of Brazil, the Ural and Olahpian; in veins in South Africa; also at Leadhills in Scotland, and in basalt in north of Ireland.

(*b.*) *Meteoric Iron.*—Steel-gray and silver-white; contains nickel, with cobalt, copper, and other substances. Polished and etched with nitric acid, the surface is marked by lines intersecting at 60° or 120°, named Widmanstadt's figures. Has fallen from the sky in very many countries,—Siberia, Brazil, North America, South Africa, Hungary, Britain and Ireland.

ORDER VI.

SULPHURETTED METALS.

Crystallization often tesseral (⅔ths), rhombic (⅓d), or hexagonal and rhombohedric (⅓th), rarely other forms. H.=1...7; G.=3·4...9. Soluble in acids, and mostly B.B. easily fusible, many yielding fumes characteristic of sulphur, arsenic, or antimony. All (with one or two exceptions of blendes) are opaque, and show metallic lustre and colour. Are all compounds of sulphur, arsenic, or antimony with metals. Occur frequently in veins, more rarely disseminated in rocks.

Family I.—Pyrites.

Crystallization tesseral, rhombic, or hexagonal, one tetragonal. Brittle, except bornite. H.=3...6·5, the iron pyrites being the harder, the copper ores the softer; G.= 4·1...8·1, but sulphur compounds = 4·1...5·3, arsenic or antimony 6...8·1, sulphur with arsenic or antimony 6...6·5. Colour mostly yellow, becoming lighter or more gray in those with less sulphur. They are all soluble in nitric acid; solutions generally coloured, and all fusible, and give out fumes.

**408. Pyrite, Iron Pyrites.—Fe″.

Tesseral, and dodecahedral-semitesseral. The cube $\infty O\infty$, then O, $\frac{\infty O2}{2}$ (fig. 236), and others (fig. 237), and macles (fig. 238). In druses or groups, spheroidal or reniform, and massive. Cleavage, hexahedral or octahedral very imperfect, or scarcely perceptible; brittle. H.=6...6·5; G.= 4·9...5·2. Bronze-yellow, inclining to gold-yellow, often with a brown or rarely variegated

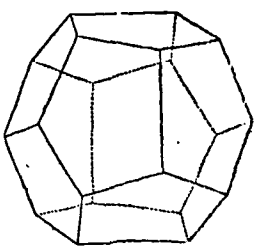


Fig. 236.

tarnish; streak brownish-black. When broken emits a smell of sulphur. B.B. on charcoal burns with a bluish

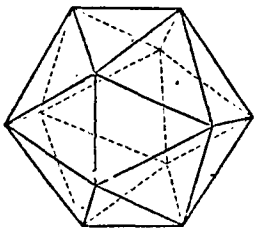


Fig. 237.

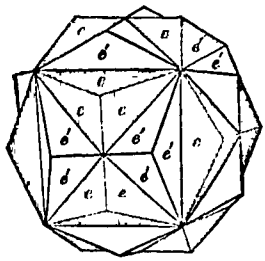


Fig. 238.

flame, and a strong smell of sulphur. In the red. flame fuses to a blackish magnetic bead. Soluble in nitric acid with deposition of sulphur; scarcely affected by h. acid. Chem. com. 46·7 iron and 53·3 sulphur. Very often contains gold, silver, or silicium, the gold occasionally in visible grains. Common in rocks of all ages and classes. Fine varieties, Elba, Cornwall, Persberg, Traversella; also Alston Moor and Derbyshire. Auriferous pyrites, Beresof, Marmato, Mexico, Aedelfors in Sweden, and many parts of England and Scotland. Used for the manufacture of sulphur, sulphuric acid, and alum.

*409. MARCASITE, White Iron Pyrites.—$\dot{F}e''$.

Rhombic; ∞P 106° 5′, $\frac{1}{3}\breve{P}\infty$ 136° 54′, $\breve{P}\infty$ 80° 20′, $\bar{P}\infty$ 64° 52′. Crystals like figs. 193 and 158; tabular or thin prismatic, or pyramidal. Macles frequent; also cocks-comb-like groups, or spherical, reniform, and stalactitic. Cleavage, ∞P indistinct, $\breve{P}\infty$ traces; fracture uneven; brittle. H.=6...6·5; G.=4·65...4·9. Pale, or grayish bronze-yellow, sometimes almost greenish-gray; streak dark greenish-gray or brownish-black. B.B. and with acids acts like pyrite. Varieties are:—*Radiated pyrites*, radiated, fibrous masses. *Spear pyrites*, macles, very fine at Littmitz, Przibram, Schemnitz, and Freiberg. *Hepatic pyrites*, or *Leberkies*, liver-brown, generally decomposing; Harz,

Saxony, Sweden, Derbyshire, and Cornwall. *Cockscomb pyrites*, compound, comb-like crystals, often greenish, or with a brown tarnish; Derbyshire and the Harz. *Wasserkies* or *Hydrous pyrites* contains water; the *Kyrosite* copper and arsenic; *Lonchidite* also arsenic.

*410. PYRRHOTINE, Magnetic Pyrites.—Fe', *or* $Fe'^5\ \dot{F}e'''$.

Hexagonal; P126° 50′. Crystals 0P . ∞P, or with P (fig. 239) tabular or short prismatic, but rare. Commonly massive, granular, or compact. Cleavage, ∞P imperfect, laminar structure along 0P; brittle. H.=3·5...4·5; G.=4·4...4·7. Colour between bronze-yellow and copper-red, with a pinchbeck-brown tarnish; streak grayish-black; more or less magnetic. Unaltered in the closed tube; in the open tube yields sulphurous fumes, but no sublimation. B.B. on charcoal in the red. flame fuses to a black strongly-magnetic globule; soluble in h. acid. Chem. com. 63·65 iron and 36·35 sulphur, or 60·44 iron and 39·56 sulphur, in some with 2 to 3 nickel. Bodenmais, Fahlun, Kongsberg, Andreasberg, Moel Elion and Llanrwst in Caernarvonshire, Cornwall, Appin in Argyleshire, and Vesuvius; also in some meteoric stones.

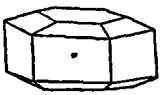


Fig. 239.

*411. LEUCOPYRITE, Arsenical Pyrites, Lölingite. } Fe As, *or* $Fe^4\ As^3$.

Rhombic; ∞P 122° 26′, $\breve{P}\infty$ 51° 20′, $\breve{P}\infty$ 86° 10′. Crystals ∞P . $\breve{P}\infty$ (fig. 240). Generally massive, granular, or columnar. Cleavage, basal rather perfect, $\breve{P}\infty$ imperfect; fracture uneven; brittle. H.=5...5·5; G.=7·0...7·4. Silver-white to steel-gray, with a darker tarnish; streak grayish-black. B.B. on charcoal emits a strong smell of arsenic, and fuses to a black magnetic globule. Chem. com. 27·2 iron and 72·8 arsenic, or 32·2 iron and 66·8 arsenic, but always 1·3 to 21 sulphur, and sometimes 13·4 nickel, and 5 cobalt. Reichenstein in

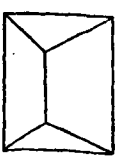


Fig. 240.

Silesia; Schladming in Styria; Löling in Carinthia; Andreasberg, in the Harz, and Fossum in Norway. Used for the manufacture of arsenious acid.

*412. MISPICKEL.—Fe S^2 + Fe As.

Rhombic; ∞P 111° 12′, ¼ P̆∞ 146° 28′, P̆∞ 79° 22′, P̄∞ 59° 2′. Crystals ∞P . ¼ P̆∞. Macles short prismatic or tabular; also massive, granular, or columnar. Cleavage, ∞P rather distinct; fracture uneven; brittle. H. = 5·5...6; G. = 6...6·2. Silver-white, almost steel-gray, with a grayish or yellowish tarnish; streak black. In the closed tube yields first a red then a brown sublimate of sulphuret of arsenic, and then metallic arsenic. B.B. on charcoal fuses to a black magnetic globule. Chem. com. 19·9 sulphur, 46·6 arsenic, and 33·5 iron, but some contain silver or gold, others 5 to 9 cobalt. Freiberg, Altenberg, Joachimsthal, Zinnwald, Schlackenwald, Andreasberg, Sweden, North America, and in many Cornish tin mines; Cobalt-mispickel, from Skutterud in Norway. *Danaite* and *Plinian* seem the same mineral. Used as an ore of arsenic or of silver.

*413. COBALTINE.—Co S^2 + Co As.

Tesseral and semitesseral, like pyrite; also massive or granular, disseminated. Cleavage, hexahedral perfect; brittle. H. = 5·5; G. = 6·0...6·3. Brilliant, silver-white, inclining to red, often with a grayish or yellowish tarnish; streak grayish-black. B.B. on charcoal fuses with strong smell of arsenic to a gray, weak magnetic globule; after roasting shows reaction for cobalt with borax. Chem. com. 35·9 cobalt (with 3·6 iron), 44·9 arsenic, and 19·2 sulphur. Skutterud in Norway, Tunaberg, Querbach in Silesia, Siegen, and St Just in Cornwall.

Glaukodote.—Rhombic like mispickel. Dark tin-white; streak black; with 11·9 iron, 24·8 cobalt. Huasco and Valparaiso in Chili, Orawitza.

*414. SMALTINE.—Co As.

Tesseral; chiefly the cube and octahedron, the faces of

the cube convex or cracked; also reticulated, reniform, or granular compact. Cleavage, traces along $\infty O \infty$ and O; fracture uneven; brittle. H.=5·5; G.=6·4...7·3. Tin-white or steel-gray, with a dark-gray or iridescent tarnish; streak grayish-black. Gives out an odour of arsenic when broken. In the closed tube gives no sublimate of arsenic. B.B. fuses easily, with a strong smell of arsenic, to a white or gray magnetic globule. Chem. com. 71·4 arsenic and 28·6 cobalt, but with 3 to 19 iron and 1 to 12 nickel; others 1 to 3 bismuth. Schneeberg, Annaberg, Riechelsdorf, Allemont in Dauphiné; Tunaberg in Sweden; Chatham in Connecticut; Huel Sparnon, Doalcoath, and Redruth in Cornwall. *Gray Smaltine* has 10 to 18 iron, and G.=6·9 to 7·3. Smaltine and cobaltine are used in preparing blue colours for painting porcelain and stoneware.

415. MODUMITE, Skutterudite.—$Co^2 As^3$.

Tesseral; O and $\infty O \infty$, or granular. Cleavage, hexahedral distinct; fracture conchoidal or uneven; brittle. H.=6; G.=6·74...6·84. Tin-white to pale lead-gray, sometimes with an iridescent tarnish. Lustre rather brilliant. In the closed tube it gives a sublimate of metallic arsenic; in other respects acts like smaltine. Chem. com. 79 arsenic, and 21 cobalt. Skutterud, near Modum in Norway.

416. LINNÉITE.—$(Ni', Co', Fe') + (\dot{N}i''', \dot{C}o''', Fe''')$.

Tesseral; in octahedrons and cubes, or macled; also massive. Cleavage, hexahedral imperfect; brittle. H. =5·5; G.=4·9...5·0. Silver-white inclining to red, often with a yellowish tarnish; streak blackish-gray. B.B. on charcoal fuses in the red. flame to a gray magnetic globule, bronze-yellow when broken. Chem. com. 11 to 53 cobalt, 0 to 42·6 nickel, 2 to 5 iron, and 1 to 15 copper. Bastnæs in Sweden, and Müsen near Siegen.

417. SYEPOORITE.—Co'.

Massive. Steel-gray or yellowish. G.=5·45. Chem. com. 65·2 cobalt, and 34·8 sulphur. Syepoor near Raj-

pootanah in North-West India. The Indian jewellers use it to give a rose colour to gold.

418. GRÜNAUITE, Saynite.

Tesseral; O and $\infty O \infty$; also granular. Cleavage octahedral; brittle. H.=4·5; G.=5·14. Light steel-gray inclining to silver-white, with a yellow or grayish tarnish. B.B. fuses to a gray, brittle, magnetic bead, yellow on the fracture, and colours the support yellow. The solution in nitric acid is green. Chem. com. nickel, bismuth, sulphur, iron, cobalt, copper, lead, in variable proportions. Grünau in Sayn-Altenkirchen.

419. GERSDORFFITE.—(Ni, Fe) As + (Ni, Fe) S^2.

Tesseral; O, $\infty O \infty$; usually granular. Cleavage, hexahedral rather perfect; fracture uneven; brittle. H.=5·5; G.=5·6...6·13 (6·64?). Silver-white to steel-gray, with a grayish tarnish. In the closed tube decrepitates violently. B.B. fuses to a brittle, black, slag-like globule; partially soluble in nitric acid. Chem. com. 35·2 nickel (with 2·4 to 6 iron, 0 to 3 cobalt), 45·4 arsenic, and 19·4 sulphur; but others give different formula, with 10 to 15 iron and 14 cobalt. Harzgerode and Tanne, Schladming, Camsdorf, Loos in Helsingland, Sweden; also Spain and Brazil. Used as an ore of nickel.

Amoibite, *Tombazite*, and *Wodankies*, are similar.

420. ULLMANNITE.—Ni Sb + Ni S^2, *or* Ni^2 (Sb, As, S)^3.

Tesseral; O, $\infty O \infty$, ∞O; usually granular. Cleavage, hexahedral perfect; fracture uneven. H.=5...5·5; G.=6·2...6·5. Lead-gray to tin-white or steel-gray; with a grayish-black or iridescent tarnish. B.B. fuses with dense fumes, and slight odour of arsenic; soluble in con. nitric acid. Chem. com. 27·4 nickel, 57·5 antimony, and 15·1 sulphur, with 2 to 12 arsenic. Westerwald, Siegen, Harzgerode, and Lobenstein.

421. BREITHAUPTITE.—Ni^2 Sb.

Hexagonal; P 112° 10′. Crystals, thin striated hexagonal tables of $0P \cdot \infty P$. H.=5; G.=7·54. Brilliant.

Light copper-red, with violet-blue tarnish. B.B. fumes and fuses with great difficulty. Chem. com. 32·2 nickel, and 67·8 antimony, but mixed with 6 to 12 sulphuret of lead. Andreasberg.

422. NICKELINE, Copper Nickel.—Ni^2 As.

Hexagonal; P 86° 50′. Crystals, ∞P, 0P (fig. 241), very rare and indistinct; also arborescent, reniform, or generally massive. Fracture conchoidal and uneven; brittle. H.=5·5; G.=7·5...7·7. Light copper-red, with a tarnish first gray then blackish. It forms no sublimate in the closed tube. B.B. fuses with strong fumes to a white, brittle, metallic globule. Chem. com. 43·6 nickel and 56·4 arsenic, but with 0 to 2 cobalt, 0·2 to 9 iron, 0·1 to 4 sulphur, and 0 to 29 antimony. Freiberg, Schneeberg, Joachimsthal, Andreasberg, Chatham in Connecticut, Pengelly and Huel Chance in Cornwall, and Leadhills in Scotland. Used as an ore of nickel.



Fig. 241.

Plakodine is a furnace product, not a native mineral.

423. RAMMELSBERGITE, White Nickel.—Ni As.

Tesseral; O, ∞O∞, ∞O; also fine granular or compact. Fracture uneven; brittle. H.=5·5; G.=6·4...6·6. Tin-white, but first a gray, then a blackish tarnish, and loses its lustre. Yields an odour of arsenic when broken. In the closed tube forms a sublimate of metallic arsenic, and becomes copper-red. B.B. on charcoal fuses easily with much smoke, continues long ignited, becomes invested with crystals of arsenious acid, and leaves a brittle grain of metal. Chem. com. 28 nickel and 72 arsenic, but often with cobalt; and many smaltines belong to this species. Schneeberg, Riechelsdorf, Allemont.

424. CHLOANTHITE.—Ni As.

Rhombic; ∞P 123°...124°. G.=7·099...7·188. Colour tin-white, inclining to red on the fresh fracture. Otherwise like Rammelsbergite, with which it occurs. The names are sometimes transposed.

425. MILLERITE.—Ni'.

Rhombohedric; R 144° 8', in fine acicular prisms of ∞P2 . R. Brittle. H.=3·5; G.=4·6, or 5·26, and 5·65. Brass or bronze yellow, with a gray or iridescent tarnish. B.B. fuses easily to a blackish metallic globule, which boils and sputters. In nitro-chloric acid forms a green solution. Chem. com. 64·4 nickel and 35·6 sulphur. Johann-Georgenstadt, Joachimsthal, Przibram, Camsdorf, Riechelsdorf, near St Austle in Cornwall, and at Merthyr Tydvil.

426. INVERARITE, Eisennickelkies.—2 Fe' + Ni'.

Tesseral; massive and granular. Fracture uneven; brittle. H.=3·5...4; G.=4·6. Light pinchbeck-brown, with darker streak. Not magnetic. B.B. acts in general like pyrrhotine; the roasted powder forms with borax in the red. flame a black opaque glass. Chem. com. 36 sulphur, 42 iron, and 22 nickel; but mixed with phyrrhotine and chalcopyrite. Lillehammer in Southern Norway, near Inverary in Scotland.

**427. CHALCOPYRITE, Yellow Copper Ore, Copper Pyrites. } Cu' + Fe', *or* Cu' + Fe'''.

Tetragonal and sphenoidal-hemihedric; ½ P (*P*) with

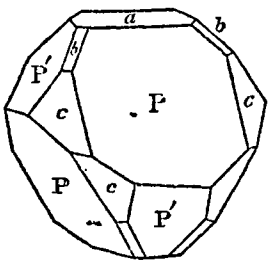


Fig. 242.

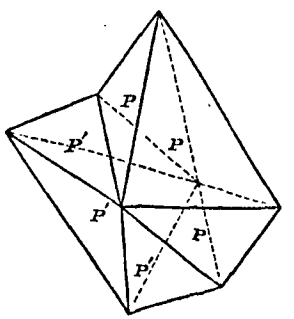


Fig. 243.

polar edges 71° 20'; P∞ (*b*), 2 P∞ (*c*) 126° 11', 0P (*a*), P and ∞P∞. Crystals generally small and deformed

(fig. 242); macles very common, like fig. 243. Most commonly compact and disseminated; also botryoidal and reniform. Cleavage, pyramidal 2 P∞ sometimes rather distinct; fracture conchoidal or uneven. H.=3·5...4; G.=4·1...4·3. Brass-yellow, often with a gold-yellow or iridescent (*peacock copper ore*) tarnish; streak greenish-black. B.B. on charcoal becomes darker or black, and on cooling red. Fuses easily to a steel-gray globule, which at length becomes magnetic, brittle, and grayish-red on the fractured surface. With borax and soda yields a grain of copper. Moistened with h. acid colours the flame blue. Chem. com. essentially 1 atom copper, 1 atom iron, and 2 atoms sulphur, with 34·5 copper, 30·5 iron, and 35 sulphur. The most abundant ore of copper. Anglesea (Parys Mine), Derbyshire, Staffordshire, Cumberland; Wicklow in Ireland; also in the Cornish mines (Gunnis Lake and St Austle); in Scotland in Kirkcudbrightshire and Wigtownshire, Tyndrum in Perthshire, Inverness-shire, Zetland, and other places. Of foreign European localities, Fahlun, Roraas, Freiberg, Mansfeld, Goslar, Lauterberg, Musen, may be mentioned; also in Siberia, the United States, and Australia. The ores raised in Cornwall and Devon give 8 per cent. metal on the average; and that picked for sale at Redruth rarely yields 12, sometimes only 3 or 4 per cent. The richness of the ore may in general be judged of by the colour; if of a fine yellow hue, and yielding readily to the hammer, it may be considered a good ore; but if hard and pale yellow, it is assuredly a poor one, being mixed with iron pyrites. From pyrite it is distinguished by yielding readily to the knife, by its tarnish, and by soon forming a green solution in nitric acid.

Cuban.—$\dot{C}u'\ddot{F}e''' + 2\,\dot{F}e$. Tesseral in cubes or massive, with a hexahedral cleavage. G.=4·02...4·04. B.B. very easily fusible, otherwise like chalcopyrite. Chem. com. 22·96 copper, 42·51 iron, and 34·78 sulphur. Bacaranao in Cuba.

*428. BORNITE, Variegated or Purple Copper. } $\dot{C}u^{3}\,\dot{F}e'''$.

Tesseral. Crystals, $\infty O\infty$, and $\infty O\infty$. O, but rare, and generally rough or uneven; also macles. Mostly massive. Cleavage, octahedral very imperfect; fracture conchoidal or uneven; slightly brittle, or almost sectile. H.=3; G.=4·9...5·1. Colour between copper-red and pinchbeck-brown, with very pale tarnish, especially steel-blue, inclining to red and green; streak grayish-black. B.B. acts like chalcopyrite; soluble in con. h. acid, leaving sulphur. Chem. com. 3 atoms copper, 1 atom iron, and 3 atoms sulphur, with 55·6 copper, 16·4 iron, and 28 sulphur, but often, especially when compact, mixed, and then 56 to 71 copper, and 6 to 17 iron. Crystals near Redruth and St Day in Cornwall; massive at Killarney in Ireland; also Norway, Sweden, Mansfeld, Silesia, Tuscany, and Chili. An ore of copper.

429. DOMEYKITE.—$\dot{C}u^{6}$ As.

Botryoidal, reniform, or massive. Fracture uneven or conchoidal; brittle. H.=3...3·5. Tin or silver white, inclining to yellow, with an iridescent tarnish. B.B. fuses easily with strong odour of arsenic; not affected by h. acid. Chem. com. 71·63 copper and 28·37 arsenic. Calabazo in Coquimbo and Copiapo in Chili.

Condurrite.—Massive, soft, and soils the fingers. Fracture flat conchoidal. Colour brownish or bluish black. G.=4·20...4·29. B.B. on charcoal fuses, with escape of arsenic vapours, to a globule, which, on cooling, cracks, swells, and falls to pieces. With soda and borax leaves a grain of copper. Seems an impure variety. Condurrow Mine and near Redruth in Cornwall.

430. ARSENIURET OF MANGANESE.—Mn^{2} As.

Massive and botryoidal, granular or foliated. Fracture uneven; brittle. G.=5·55. Grayish-white, with a black tarnish. B.B. burns with a blue flame, and emits fumes of arsenic; soluble in nitro-chloric acid. Chem. com. 42·75 manganese, 57·25 arsenic, with trace of iron. Saxony.

Family II.—Lead Glance.

Crystallization, chiefly tesseral; also rhombic and rhombohedric. H.=1···2·5, rarely more; G.=4·6...8·9, and mostly 5·5, or higher. Colours generally lead-gray, and more or less dark. All soluble in acids. B.B. all fusible, and mostly very easily, and easily reduced. They are compounds with sulphur, arsenic, or selenium; known by their fumes. Chiefly occur in veins.

*431. Galena, Sulphuret of Lead.—Pb'.

Tesseral; $\infty O \infty$, ∞O; seldomer 2O, and 2O2. Crystals, $\infty O \infty$. O. Also massive and granular, compact, or laminar. Cleavage, hexahedral very perfect; fracture scarcely observable; sectile. H.=2·5; G.=7·2...7·6. Lead-gray, with darker, or rarely iridescent tarnish; streak grayish-black. B.B. decrepitates, fuses, and leaves a globule of lead; soluble in nitric acid. Chem. com. 86·7 lead and 13·3 sulphur, but usually contains a little silver,—ranging from 1 to 3, or 5 parts in 10,000; rarely 1 per cent. or more. Some contain copper, zinc, or antimony, others selenium, and others (the *supersulphuret*) probably free sulphur (2 to 8 per cent.) Most common ore of lead in many countries. Cornwall, Derbyshire (Castletown), Wales, Cumberland, Alston Moor, Durham (Allenhead); Isle of Man; Leadhills, Pentland Hills, Linlithgow, Inverkeithing, Monaltrie, Tyndrum, Strontian, Islay, and many other places in Scotland. In 1855 the produce was,—England, 66,265 tons; Wales, 18,204; Isle of Man, 3573; Ireland, 2005; and Scotland, 1587 tons.

432. Cuproplumbite.—Cu' Pb'^2.

Tesseral; massive, with distinct hexahedral cleavage. Rather sectile and brittle. H.=2·5; G.=6·408...6·428. Blackish lead-gray; streak black. B.B. does not decrepitate; with soda gives a grain of metal. Chem. com.

65 lead, 19·9 copper, and 15·1 sulphur (with 0·5 silver). Chili.

433. CLAUSTHALITE.—Pb Se.

Tesseral; but massive and fine granular, with hexahedral cleavage. H.=2·5...3; G.=8·2...8·8. Lead-gray; streak gray. B.B. on charcoal fumes, smells of selenium, colours the flame blue, stains the support red, yellow, and white; and volatilizes, except a small remainder, without fusing. Chem. com. 72·7 lead (with 11·6 silver), and 27·3 selenium. Lerbach, Zorge and Tilkerode in the Harz.

Tilkerodite, with 3 cobalt; G.=7·7; colours borax glass smalt-blue. *Lehrbachite;* Lerbach and Tilkerode; with 17 to 45 mercury, seems a mixture.

434. SELENCOPPERLEAD.—(Cu, Pb) Se.

Massive and fine granular. Sectile. H.=2·5; G.=7 ...7·5. Light lead-gray inclining to brass-yellow, or with a bluish tarnish; streak darker. B.B. like clausthalite, only some fuse slightly on the surface, others easily forming a gray metallic mass. Chem. com. 30 to 35 selenium, 47 to 64 lead, and 4 to 16 copper (with 0 to 1·3 silver). Tilkerode, Zorge, and near Gabel in Thuringia.

435. ONOFRITE.—Hg Se + 4 Hg S.

Massive, and granular. H.=2·5. Blackish lead-gray or steel-gray; streak shining. In the closed tube wholly volatile with a black sublimate. With soda gives metallic mercury. Chem. com. 82·8 mercury, 6·6 selenium, and 10·6 sulphur. St Onofre in Mexico, Zorge in the Harz.

436. TIEMANNITE.—Hg Se, *or* $Hg^6 Se^5$.

Fine granular; brittle. H.=2·5; G.=7·1...7·4. Brilliant. Dark lead-gray. In the closed tube decrepitates, swells, fuses, and volatilizes to a black and brown deposit. Only soluble in nitro-chloric acid. Chem. com. 75 mercury, 25 selenium. Clausthal.

437. NAUMANNITE.—Ag Se.

In thin plates and granular. Cleavage, hexahedral perfect. Malleable. H.=2·5; G.=8. Iron-black; splen-

dent. B.B. on charcoal fuses; with soda a grain of silver; easily soluble in con. nitric acid. Chem. com. 73 silver and 27 selenium, with 4·91 lead. Tilkerode.

Silverphyllinglanz.—Massive, foliated; perfect cleavage; thin lamina flexible. H.=1...2; G.=5·8...5·9. Dark-gray. Chem. com. antimony, lead, tellurium, gold, and sulphur (*Plattner*). Deutsch-Pilsen in Hungary.

*438. ARGENTITE, Sulphuret of Silver.—$\dot{A}g$.

Tesseral; $\infty O\infty$, O, ∞O, and 2O2 (fig. 244). Crystals generally misshapen, with uneven or curved faces; in druses, or linear groups; also arborescent, capillary, or in crusts. Cleavage, very indistinct traces along ∞ O and $\infty O\infty$; fracture uneven and hackly; malleable and flexible. H.=2...2·5; G.=7...7·4. Rarely brilliant; more so on the streak. Blackish lead-gray, often with a black, brown, or rarely iridescent tarnish. B.B. on charcoal fuses, intumesces greatly, and leaves a grain of silver; soluble in con. nitric acid. Chem. com. 87 silver, and 13 sulphur. Freiberg, Marienberg, Annaberg, Schneeberg, Johann-Georgenstadt; Joachimsthal; Schemnitz and Kremnitz; Kongsberg; Huel Duchy, Dolcoath, Herland, and near Callington, in Cornwall; Alva in Stirlingshire. Common ore at Guanaxuato and Zacatecas in Mexico, in Peru, and Blagodat in Siberia. Valuable ore of silver.

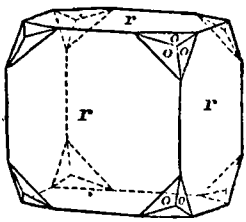


Fig. 244.

439. STROMEYERITE.—$\dot{C}u' + \dot{A}g'$.

Rhombic; isomorphous with redruthite. Crystals rare; usually massive, or in plates; fracture flat, conchoidal, or even; very sectile. H.=2·5...3; G.=6·2...6·3. Bright. Blackish lead-gray. B.B. fuses easily to a gray metallic semimalleable globule. Chem. com. 52·9 silver, 31·4 copper, and 15·7 sulphur, but often indeterminate proportions of silver 3 to 53, and copper 30 to 75. Schlangenberg in

Siberia, Rudelstadt in Silesia, and Catemo in Chili. Ore of silver and copper.

*440. REDRUTHITE, Copper Glance.—$\dot{C}u'$.

Rhombic; ∞P (*o*) 119° 35′, P (*P*) middle-edge 125° 22′, $\frac{1}{3}P$ (*a*) middle-edge 65° 40′, $2\breve{P}\infty$ (*d*) middle-edge 125° 40′, $\frac{2}{3}\breve{P}\infty$ (*e*) middle-edge 65° 48′. Crystals 0P . (*s*) ∞P . (*o*) $\infty\breve{P}\infty$ (*p*), (fig. 245). Mostly thick tabular; also macles; and massive, in plates or lumps. Cleavage, ∞P imperfect; fracture conchoidal or uneven; very sectile. H.= 2·5...3; G.=5·5...5·8. Rather dull; brighter on the streak. Blackish lead-gray, with a blue or other tarnish. B.B. colours the flame blue; on charcoal in the ox. flame sputters and fuses easily; in the red. flame becomes solid. With soda gives a grain of copper. Green solution in nitric acid. Chem. com. 79·8 copper, and 20·2 sulphur., Saxony, Silesia, Norway, the Bannat, Siberia, and the United States; near Redruth and Land's End in Cornwall; Fassnet Burn in Haddingtonshire, in Ayrshire, and in Fair Island, Orkney. Important copper ore.

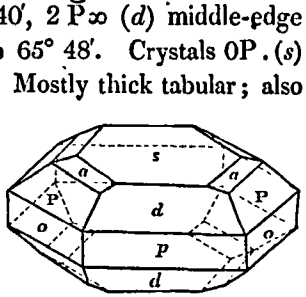


Fig. 245.

Digenite.—Massive. G.=4·568...4·680; in other respects like redruthite. Contains 70·20 copper, 29·56 sulphur, and 0·24 silver. Sangerhausen in Thuringia, and Chili.

441. KUPFERINDIG, Covelline.—Cu'.

Hexagonal. Crystals ∞P . 0P rare; usually reniform, and fine granular. Cleavage, basal often very perfect; sectile, and thin laminæ flexible. H.=1·5...2; G.=3·8 ...3·85. Dull resinous, inclining to metallic. Indigo-blue, inclining to black; streak black. B.B. burns with a blue flame; on charcoal like redruthite, but remains fluid in the inner flame; soluble in nitric acid. Chem. com. 66·7 copper, and 33·3 sulphur. Vesuvius, Sangerhausen, Baden-

weiler, Schwarzwald; Kielce in Poland, Leogang in Salzburg, and Cairn Beg in Cornwall.

442. EUKAIRITE.—Cu^2 Se + Ag Se.

Massive and fine granular. Soft (cuts with the knife). Lead-gray; streak shining. B.B. fuses to a brittle gray metallic grain. Chem. com. 43 silver, 25·2 copper, and 31·8 selenium. Skrickerum in Smoland.

443. BERZELINE.—Cu^2 Se.

Crystalline, in thin dendritic crusts. Soft. Silver-white; streak shining. B.B. on charcoal fuses to a gray, slightly malleable bead. With soda a grain of copper. Chem. com. 61·5 copper and 38·5 selenium. Skrickerum in Sweden, Lerbach in the Harz.

444. NAGYAGITE, Black or Foliated Tellurium.

Tetragonal; P 137° 52′, P∞ 122° 50′, and 0P. Crystals tabular, but rare; in general thin plates or foliated. Cleavage, basal very perfect; very sectile; the thin laminæ flexible. H.=1...1·5; G.=6·85...7·2. Splendent. Blackish lead-gray. B.B. fuses easily, with white fumes, and forms a yellow deposit on the charcoal; with soda leaves a grain of gold; soluble in nitric acid, with residue of gold. Chem. com. 51 to 63 lead, 6·7 to 9 gold, 1 to 1·3 copper and silver, 13 to 32 tellurium, 3 to 12 sulphur, and 0 to 4·5 antimony. Nagyag in Siebenburg, and Offenbanya.

445. ALTAITE.—Pb Te.

Tesseral and granular; hexahedral cleavage. Fracture uneven; sectile. H.=3...3·5; G.=8·1...8·2. Tin-white inclining to yellow, with yellow tarnish. B.B. on charcoal colours the flame blue; in the red. flame fuses to a globule that almost wholly volatilizes. Chem. com. 61·9 lead with 1·28 silver, and 38·1 tellurium. Sawodinski mine in the Altai.

446. HESSITE.—Ag Te.

Massive and granular; slightly malleable. H.=2·5...3; G.=8·31...8·83. Blackish lead-gray to steel-gray. B.B. on charcoal fumes, fuses to a black grain with white spots,

and leaves a brittle grain of silver. Chem. com. 62·8 silver, and 37·2 tellurium, but some (*Petzite*) 0·7...18 gold. Sawodinski mine in the Altai, Nagyag in Siebenburg.

447. TETRADYMITE.—2 Bi Te^3 + Bi S^3.

Rhombohedric; 3 R 66° 40′. Crystals 3 R . 0R; almost always macles, with the faces of 0R at 95°; also granular foliated. Cleavage, basal very perfect; sectile, and in thin laminæ flexible. H.=1...2; G.=7·2...7·5. Dull. Tin-white to steel-gray. B.B. on charcoal fuses easily, occasionally with odour of selenium, staining the support yellow and white; at length yields a white grain of metal, almost entirely volatile; soluble in nitric acid. Chem. com. 59·66 bismuth, 35·86 tellurium, and 4·48 sulphur, with traces of selenium; but the tellurium and bismuth are isomorphous, and probably in indeterminate proportions, the sulphur and selenium not essential. Schubkau near Schemnitz, Deutsch-Pilsen in Hungary, San Jose in Brazil, Virginia and Carolina.

*448. MOLYBDENITE.—$Mo^{''}$.

Hexagonal; but only tabular or short prismatic crystals of 0P . ∞P or 0P . P. Generally scaly or curved foliated. Cleavage, basal very perfect; very sectile, and thin laminæ flexible. Feels greasy. H. = 1...1·5; G.=4·6...4·9. Reddish lead-gray; makes a gray mark on paper, a greenish mark on porcelain. B.B. in the forceps, colours the flame siskin-green, but is infusible. On charcoal yields sulphurous fumes, and forms a white coating, but burns slowly and imperfectly. In warm nitrochloric acid forms a greenish, in boiling sulphuric acid a blue solution. Chem. com. 59 molybdena and 41 sulphur. Arendal, Altenberg, Ehrenfriedersdorf, Zinnwald, Schlackenwald, Mont Blanc, Shutesbury in Massachusetts, in Maine, Haddam in Connecticut; Caldbeckfell in Cumberland, Shap in Westmoreland, Huel Gorland, and many Cornish mines; Peterhead, Corybuy on Loch Creran, and Glenelg. Readily distinguished from graphite by its streak, lustre, gravity, and

action before the blowpipe. Used for preparing blue carmine for colouring porcelain.

Family III.—Gray Antimony Ore.

Crystallization rhombic, rarely tesseral or hexagonal. H.=3...3·5, or less; G.=4...6·8 (sylvanite 8·1). Colour steel or lead gray. All soluble in acids with precipitates; generally very easily fusible, even in the flame of a candle, and give out fumes.

*449. Stibine, Antimonite.—Sb'''.

Rhombic; P polar edges 109° 16′, and 108° 10′, ∞P 90° 45′. Crystals ∞P (*m*) . $\infty \breve{P}\infty$ (*o*) . P (*P*), or with $\frac{1}{2}\breve{P}\infty$ (*a*), $2\breve{P}2$ (*b*), $\frac{2}{3}\breve{P}2$ (*e*), $\frac{1}{3}P$ (*s*), (fig. 246). Mostly long prismatic or acicular, with strong vertical striæ, often in druses or stellar groups; also radiating, fibrous, or fine granular. Cleavage, brachydiagonal (*o*) highly perfect, and often horizontally striated; also basal, ∞P, and macrodiagonal imperfect; sectile. H.=2; G.=4·6 ...4·7. Brilliant. Lead-gray, with a blackish or iridescent tarnish. B.B. fuses easily, colouring the flame green, and volatilizes, leaving a white coating on the support; soluble in warm h. acid. Chem. com. 71·8 antimony and 28·2 sulphur. Near Freiberg in Saxony, Wolfsberg in the Harz, Przibram, Felsöbanya, Kremnitz, Schemnitz, Auvergne, Spain, and North and South America; St Stephen's, Padstow, and Endellion in Cornwall; Glendinning in Dumfriesshire, New Cumnock in Ayrshire, and in Banffshire. Chief ore of antimony.

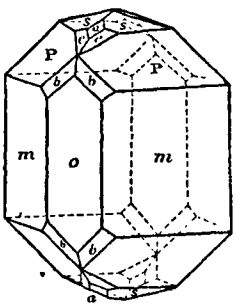


Fig. 246.

450. Jamesonite.—$Pb'^3\,Sb'''^2$.

Rhombic; ∞P 101° 20′. Crystals ∞P . $\infty \breve{P}\infty$, long pris-

matic, parallel or radiating. Cleavage, basal very perfect, ∞P and brachydiagonal imperfect; sectile. H.=2...2·5; G.=5·5...5·7. Steel-gray to dark lead-gray. B.B. decrepitates, fuses easily, and wholly volatilizes, except a small slag; soluble in warm h. acid. Chem. com. 44·6 lead, with 2 to 4 iron, 34·8 antimony, and 20·6 sulphur. Cornwall, Estremadura, Hungary, Siberia, and Brazil.

451. ZINCKENITE.—$Pb' Sb'''$.

Rhombic; ∞P 120° 39′, $\breve{P}\infty$ 150° 36′. Crystals, prismatic or acicular, vertically striated, and macled in threes. Cleavage, prismatic very imperfect; fracture uneven; rather sectile. H.=3...3·5; G.=5·30...5·35. Dark steel-gray to lead-gray, with a steel-blue or iridescent tarnish. B.B. decrepitates violently, fuses, emits fumes of antimony, and wholly volatilizes, except a small remainder; soluble in warm h. acid. Chem. com. 35·9 lead, 42 antimony, 22·1 sulphur, with 0·42 copper. Wolfsberg in the Harz.

452. PLAGIONITE.—$Pb'^4 Sb'''^3$.

Monoclinohedric; C=72° 28′, P 134° 30′ and 142° 3′ −2 P 120° 49′. Crystals thick tabular, minute, and in druses. Cleavage, −2 P rather perfect; brittle. H.=2·5; G.=5·4. Blackish lead-gray. B.B. decrepitates violently, fuses easily, sinking into the charcoal, and leaves metallic lead. Chem. com. 42 lead, 37 antimony, and 21 sulphur. Wolfsberg in the Harz.

453. BOULANGERITE.—$Pb'^5 Sb'''^2$.

Fine granular, columnar, radiating, or fibrous. Slightly sectile. H.=3; G.=5·8...6. Silky, metallic. Blackish lead-gray, with darker streak. B.B. fuses easily, forming a coating of protoxide of lead; soluble in warm h. acid. Chem. com. 55·4 lead, 25·9 antimony, and 18·7 sulphur. Molières in France, Ober-Lahr, Lapland, and Siberia. *Plumbostib*, with arsenic, and *Embrithite*, seem varieties; Nertschinsk.

454. GEOKRONITE.—Pb'^5 (Sb''', As''').

Rhombic; P polar edges 153° and 64° 45′, $\infty\breve{P}2$=119°

44′, mostly massive, or lamellar. Cleavage, $\infty\breve{P}2$; fracture conchoidal or even; sectile. H.=2...3; G.=6·45... 6·54. Pale lead-gray, with a slight tarnish. B.B. fuses easily and volatilizes. Chem. com. 67 lead, with 1 to 2 copper and iron, 16 antimony, with 4·7 arsenic, and 17 sulphur. Sala in Sweden, Mérédo in Spain, and near Pietrosanto in Tuscany. *Kilbrickenite*, massive, granular, or foliated; County Clare in Ireland.

455. STEINMANNITE.—Pb', Sb'''.

Tesseral; O; also botryoidal and reniform. Cleavage, hexahedral rather imperfect; sectile. H.=2·5; G.=6·833. Lead-gray. B.B. decrepitates violently; on charcoal fuses readily, leaving lead and silver. Przibram.

456. PLUMOSITE, Feather Ore.—Pb'^3 Sb'''.

Rhombic (?); acicular or capillary, in felt-like masses. H. =1...3; G.=5·7...5·9. Dull or glimmering. Dark-lead or steel-gray, sometimes iridescent. B.B. and with acids acts like zinckenite; fuses even in the flame of a candle. Chem. com. 51·8 lead, 29·7 antimony, and 19·5 sulphur. Wolfsberg, Andreasberg, and Clausthal; Neudorf in Anhalt, Freiberg, and Schemnitz.

457. ENARGITE.—Cu'^3 As'''

Rhombic; ∞ P 97° 53′, $\breve{P}\infty$ 100° 58′, mostly massive and granular. Cleavage, ∞P perfect, brachy- and macro-diagonal less so; brittle. H.=3; G.=4·43...4·45. Iron-black. In the closed tube yields first sulphur, then fuses and gives out sulphuretted arsenic. B.B. with borax, gives a bead of copper. Chem. com. 48·3 copper, 19·1 arsenic, and 32·6 sulphur. Morocacha in Peru.

458. DUFRENOYSITE.—Cu'^2 As'' + Cu'^2 As''.

Tesseral. Crystals ∞O .2O2. Fracture uneven; brittle. H.=2...3; G.=4·48. Steel-gray; streak reddish-brown. In the closed tube gives a reddish-brown sublimate. B.B. fuses easily, leaving a grain of copper readily soluble in warm acid. Chem. com. 38·4 copper, 2·8 lead, 1·3 silver, 30·5 arsenic, and 27 sulphur. Binnenthal, St Gotthardt.

459. SKLEROKLASE.—$Pb'^{2}\,As'''$.

Rhombic; $\breve{P}\infty$ 115° 16′, $\breve{P}\infty : \bar{P}\infty = 134° 59'$. Crystals broad prismatic, acicular or fibrous; very brittle and friable. G. = 5·39...5·55. Bright metallic. Pale lead-gray, steel-gray, and iron-black; streak reddish-brown. Chem. com. 57·12 lead, 20·74 arsenic, 22·14 sulphur, with traces of silver, copper, and iron. St Gotthardt, with Dufrenoysite, for which it was analyzed.

460. WOLFSBERGITE.—$\dot{C}u'\,Sb'''$.

Rhombic; ∞P 135° 12′, $\infty\breve{P}2$ 111°. Crystals tabular; also fine granular. Cleavage, brachydiagonal very perfect, basal imperfect; fracture conchoidal or uneven. H. = 3·5; G. = 4·748. Lead-gray to iron-black, sometimes iridescent; streak black, dull. B.B. decrepitates, fuses easily, and with soda gives a grain of copper. Chem. com. 25·4 copper, 49 antimony, and 25·6 sulphur. Wolfsberg in the Harz.

461. BERTHIERITE.—Fe', Sb'''.

Massive; columnar or fibrous, with indistinct cleavage. H. = 2...3; G. = 4·0...4·3. Dark steel-gray, yellowish or reddish; easily tarnished. B.B. on charcoal fuses easily, with fumes of antimony, to a black magnetic slag; soluble in h. acid. Chem. com. sulphurets of iron and antimony in variable proportions, or 9·8 to 16 iron, 52 to 61·6 antimony, and 29·1 to 31 sulphur. Auvergne and Anglar in France, Bräunsdorf in Saxony, Tintagel and Padstow in Cornwall. In France used as an ore of antimony.

462. BISMUTHINE—Bi'''.

Rhombic; ∞P 91° 30′. Crystals long prismatic or acicular, with strong striæ; also granular or columnar, foliated or radiated. Cleavage, brachydiagonal perfect, macrodiagonal less distinct; sectile. H. = 2...2·5; G. = 6·4...6·6. Light lead-gray to tin-white, with a yellowish or iridescent tarnish. B.B. on charcoal fuses easily in the inner flame, sputters, and yields a yellow coating with a grain of bismuth; soluble in nitric acid. Chem. com. 81·2 bismuth and 18·8 sulphur. Riddarhyttan, Bastnaes, Johann-Georgenstadt,

Altenberg, Joachimsthal; Haddam in Connecticut; near Redruth, Botallack, Dolcoath, and Herland in Cornwall, and Caldbeckfell in Cumberland.

463. ACICULITE, Needle-ore.—$Pb'^4\ Bi''' + Cu'^2\ Bi'''$.

Rhombic; long thin crystals imbedded in quartz, often bent or broken, with strong vertical striæ. Cleavage imperfect; fracture conchoidal or uneven; rather brittle. H.=2·5; G.=6·7...6·8. Blackish lead-gray or steel-gray, with a brownish tarnish. B.B. fuses very easily, smokes, stains the charcoal white and yellow, and leaves a metallic globule; soluble in nitric acid. Chem. com. 35·8 lead, 11 copper, 36·7 bismuth, and 16·5 sulphur. Beresof in Siberia.

464. KOBELLITE.—$3\ Pb'^3\ Bi''' + Fe'^3\ Sb'''^2$.

Radiated columnar; soft. G. = 6·29...6·32. Blackish lead-gray to steel-gray; streak black. B.B. fuses (at first boiling, then quietly), and stains the charcoal white and yellow, and leaves a white grain of metal; soluble in con. h. acid, evolving sulphuretted hydrogen. Chem. com. 46 sulphuret of lead, 33·3 sulphuret of bismuth, 5·7 sulphuret of iron, and 15 sulphuret of antimony. Hvena in Nerike, Sweden.

465. SILVANITE.—$Ag\ Te^4 + Au\ Te^3$.

Rhombic; crystals generally small, short acicular, and often grouped in rows like letters. Cleavage in two directions, one very perfect; sectile, but friable. H.=1·5...2; G.=7·99...8·33. Steel-gray to tin-white, silver-white, and pale bronze-yellow. B.B. on charcoal forms a white coating, and fuses to a dark-gray globule, with soda reduced to a malleable grain of argentiferous gold; soluble in nitro-chloric acid, depositing chloride of silver; and in nitric acid, leaving gold. Chem. com. 59·6 tellurium, with 0·5 to 8·5 antimony, 26·5 gold (in some 30), and 13·9 silver, with 0·2 to 19·5 lead. Offenbanya (*Graphic Tellurium*), Nagyag (*Yellow Tellurium*).

Family IV.—Gray Copper Ore.

Crystallization rhombic and tesseral. H. = 1...4, the ores of copper being above 3, the ores of silver below 3; G. = 4·2...6·3. Colour steel or lead gray, in a few inclining to black or brown. All soluble in nitric acid. B.B. fusible, often easily, with fumes of sulphur or arsenic. Mostly sulphurets of copper and silver, with sulphurets of arsenic or antimony.

*466. Fahlore, Gray Copper. $(Cu', Ag', Fe', Zn', Hy')^4 (Sb''', As''')$.

Tesseral and tetrahedral. In crystals $\frac{O}{2}, -\frac{O}{2}, \infty O, \frac{2O2}{2}$ (fig. 247, and figs. 19, 20). Macles (fig. 248), not uncommon; most abundant massive and disseminated. Cleavage,

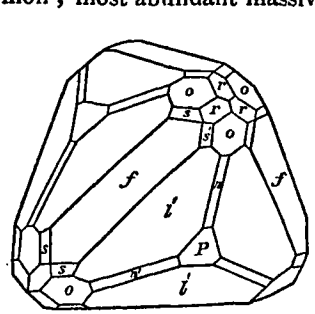


Fig. 247.

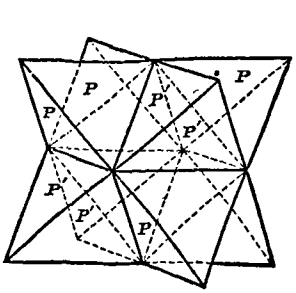


Fig. 248.

octahedral imperfect, with traces in other directions; fracture conchoidal, uneven, or fine granular; brittle. H. = 3 ...4; G. = 4·5...5·2. Steel-gray to iron-black; streak black (dark-red when containing zinc). B.B. on charcoal boils slightly, and fuses to a steel-gray slag, usually magnetic, and with soda gives copper. In nitric acid the powder forms a brownish-green solution. Chem. com. very variable; but 15 to 40 copper, 0 to 31 silver, 1 to 6 iron, 1 to 7 zinc, 0 to 7·5 mercury, 12 to 29 antimony, 0 to 10

arsenic, and 23 to 27 sulphur; those with much arsenic are paler coloured; those with little or no arsenic dark-coloured; those with 17 to 31 silver are the silver fahlore (Freiberg). Harz, Müsen, Freiberg, Camsdorf, Alsace, Kremnitz, Kapnik; Crinnis and other Cornish mines near St Austle; Airthrie near Stirling, and Sandlodge in Zetland. Ore of copper and silver.

467. TENNANTITE.—$(\dot{C}u', Fe')\ As'''$.

Tesseral; like fahlore. Cleavage, ∞O very imperfect; brittle. H.=4; G.=4·3...4·5. Blackish lead-gray to iron-black; streak dark reddish-gray. B.B. decrepitates, burns with a bluish flame and odour of arsenic, and fuses to a magnetic slag. Chem. com. 49 copper, 4 iron, 19 arsenic, and 28 sulphur. Redruth and St Day, Cornwall, and Skutterud. *Copperblende*, with brownish-red streak; G. =4·3; contains 8·9 zinc; Freiberg.

468. BOURNONITE.—$Pb'^4\ Sb''' + \dot{C}u'^2\ Sb'''$.

Rhombic; ∞P (*d*) 93° 40′, $\breve{P}\infty$ (*n*) 96° 13′, $\bar{P}\infty$ (*e*) 92° 34′, 0P (*r*), $\infty\breve{P}\infty$ (*s*), $\infty\bar{P}\infty$ (*k*), as in fig. 249. Crystals generally thick tabular, very often macled by a face of ∞P, and several times repeated; also granular or disseminated. Cleavage, brachydiagonal imperfect, traces in other directions; fracture uneven to conchoidal; rather brittle. H.=2·5...3; G.=5·7...5·9. Lustre brilliant metallic. Steel-gray, inclining to lead-gray and iron-black. B.B. usually decrepitates and fuses easily to a black globule, staining the charcoal first white, then yellow, and with soda leaves a grain of copper. In nitric acid a blue solution. Chem. com. 41·8 lead, 12·9 copper, 26 antimony, and 19·3 sulphur. Harz (Neudorf), Bräunsdorf, Kapnik, Servoz, Alais and Pontgibaud, Redruth and Beeralston.

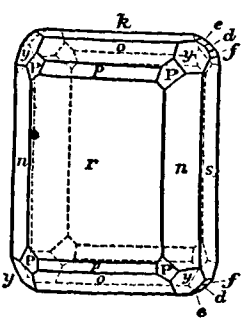


Fig. 249.

469. Wölchite.—$Cu'^4\ Sb''' + Pb'^2\ As'''$ (?).

Rhombic; in short prisms. Cleavage, brachydiagonal rather distinct; fracture imperfect conchoidal; brittle. H. = 3; G. = 5·7...5·8. Blackish lead-gray. B.B. on charcoal fuses with effervescence to a lead-gray metallic grain. Chem. com. 29·90 lead, 17·35 copper, 1·40 iron, 16·65 antimony, 6·04 arsenic, and 28·60 sulphur. Wölch, near St Gertraud, Carinthia.

470. Freieslebenite.—$Ag'^2\ Sb''' + Pb'^3\ Sb'''$.

Monoclinohedric; C = 87° 46′; ∞P 119° 12′, P∞ 131° 41′, in prisms with curved reed-like faces and strong vertical striæ. Macles intersecting; also massive. Cleavage, ∞P perfect; fracture conchoidal or uneven; rather brittle. H. = 2...2·5; G. = 6·2...6·4. Steel-gray to dark lead-gray; streak the same. B.B. on charcoal fuses to a grain of silver. Chem. com. 22·5 silver, 32·4 lead with copper, 20·8 antimony, and 18·3 sulphur. Rare. Freiberg in Saxony; also Kapnik and Ratiborschitz (?).

471. Stephanite.—$Ag'^6\ Sb'''$.

Rhombic; ∞P (*o*) 115° 39′, P (*P*) middle edge 104° 20′, 2 $\breve{P}\infty$ (*d*) middle edge 107° 48′, 0P′ (*s*), ∞$\breve{P}\infty$ (*p*), (fig. 250), thick tabular or short prismatic, Macles frequent, repeated three or four times; also massive. Cleavage (*d* and *p*), both imperfect; fracture conchoidal or uneven; sectile. H. = 2...2·5; G. = 6·2...6·3. Iron-black to blackish lead-gray, rarely iridescent. B.B. on charcoal (odour of arsenic) fuses to a dark-gray globule; with soda, a grain of silver. Chem. com. 70·9 silver, 13·5 antimony, and 15·6 sulphur, but with 0 to 5 iron, or 0·5 to 4 copper, and 0 to 3·3 arsenic. Freiberg, Schneeberg, Johann-Georgenstadt, and Annaberg; Joachimsthal and Przibram, Schemnitz, the Harz, Mexico, Peru, Siberia, and Cornwall. Valuable ore of silver.

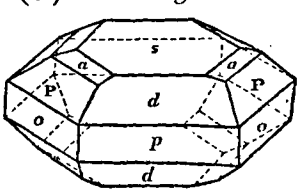


Fig. 250.

472. POLYBASITE.—$(Ag', Cu')^9 (Sb''', As''')$.

Hexagonal; P 117°. Crystals 0P . ∞P and 0P . P, tabular, and often very thin; also massive. Cleavage, basal imperfect; sectile, and easily frangible. H. = 2...2·5; G. = 6·0...6·25. Iron-black. B.B. decrepitates slightly and fuses very easily. Chem. com. 64 to 72 silver, 3 to 10 copper, 16 to 17 sulphur, 0·2 to 8 antimony, and 1 to 6 arsenic. Freiberg, Joachimsthal, Schemnitz, and Guanaxuato. An ore of silver.

473. STERNBERGITE.—$Ag' + 2\,\dot{F}e'''$ (?).

Rhombic; P middle edge 118°, section (*or* ∞P) 119° 30'. Crystals usually thin tabular, in macles or in fan-like and spheroidal groups. Cleavage, basal very perfect; sectile, and flexible in thin laminæ. H. = 1...1·5; G. = 4·2...4·25. Dark pinchbeck-brown, often a violet-blue tarnish; streak black. B.B. on charcoal fuses to a magnetic globule covered with silver, with borax, a grain of silver; decomposed by nitro-chloric acid. Zippe found 33·2 silver, 36 iron, and 30 sulphur; or nearly 1 atom silver, 4 iron, and 6 sulphur. Joachimsthal, Schneeberg and Johann-Georgenstadt.

Flexible Sulphuret of Silver is identical; Hungary and Freiberg.

474. STANNINE, Tin Pyrites.—$\dot{C}u'^2\,Sn'' + (Fe', Zn')^2\,Sn''$.

Tesseral; in cubes very rare, generally massive and granular. Cleavage, hexahedral very imperfect; fracture uneven or small conchoidal; brittle. H. = 4; G. = 4·3...4·5. Steel-gray (yellowish from copper pyrites); streak black. B.B. on charcoal fuses, forming round the assay a white coating; with soda, a grain of copper; easily decomposed by nitric acid, leaving tin peroxide and sulphur; the solution is blue. Chem. com. 26 to 32 tin, 24 to 30 copper, 5 to 12 iron, 2 to 10 zinc, and 30 sulphur. Huel Rock near St Agnes, St Michael's Mount, and Carn Brea, Cornwall; and Zinnwald. Bell-metal ore.

475. WITTICHITE, Cupreous Bismuth,—$\dot{C}u'^3\,Bi'''$.

Rhombic (?); massive. Cleavage, vertical distinct; frac-

ture uneven and fine granular; sectile. H.=3·5; G.=5. Steel-gray, pale lead-gray tarnish; streak black. B.B. fuses very readily, frothes, and stains the charcoal yellow; with soda, a grain of copper. Chem. com. 38·5 copper, 42 bismuth, and 19·5 sulphur. Wittichen in Schwarzwald. Huel Buller in Cornwall.

476. BISMUTHIC SILVER.

Acicular, capillary, or massive; sectile and soft. Pale lead-gray, darker tarnish. B.B. fuses easily, and forms a large deposit on the charcoal. Klaproth found 33 lead, 27 bismuth, 15 silver, 4·3 iron, 0·9 copper, and 16·3 sulphur. Schapbach Valley in Baden.

FAMILY V.—BLENDES.

Crystallization mostly tesseral; cleavage distinct. H. =3·5...4·5; G.=3·5...4·9. Lustre adamantine or resinous; more or less *translucent*. Colours and streak red, yellow, brown, or black. All soluble in acids. B.B. often decrepitate, but fuse with difficulty.

*477. BLENDE, Zinc-blende.—Zn'.

"Tesseral and tetrahedral; $\frac{O}{2}, -\frac{O}{2}$ (sometimes as O), ∞O, $\frac{3O3}{2}$ and $\infty O\infty$. Macles remarkably common, united by a face of O (fig. 251) and several times repeated; frequently massive and granular. Cleavage, ∞O very perfect; very brittle. H.=3·5 ...4; G.=3·9...4·2. Semitransparent to opaque; adamantine and resinous. Brown or black, also red, yellow, and green. B.B. decrepitates often violently, but only fuses on very thin edges; soluble in con. nitric acid, leaving sulphur. Chem. com. 66·8 zinc and 33·2 sulphur, but generally with 1 to 15 iron, 0 to 3 cadmium. Very abundant,

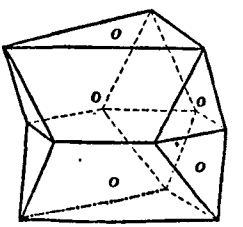


Fig. 251.

the Harz, Freiberg, Przibram, Schemnitz, Kapnik, North America, Peru, Cornwall, Derbyshire, Cumberland, Leadhills, Tyndrum, and Stotfield, near Elgin. Used as an ore of zinc, but with little success.

478. VOLTZINE.—$4\,Zn' + \dot{Z}n$.

Hemispherical, curved-lamellar incrustations. Fracture conchoidal. H. = 4·5; G. = 3·66. Brick-red to yellow or brown. Opaque or semitranslucent; vitreo-resinous; pearly. B.B. like zinc-blende; soluble in h. acid. Chem. com. 82·8 sulphuret and 17·2 oxide of zinc. Pontgibaud in Auvergne, and Joachimsthal.

479. ALABANDINE.—Mn'.

Tesseral; O and $\infty O \infty$; usually massive and granular. Cleavage, hexahedral perfect; fracture uneven; rather brittle. H. = 3·5...4; G. = 3·9...4. Opaque; semimetallic. Iron-black to dark steel-gray, brownish-black tarnish; streak dark green. B.B. fuses on thin edges to a brown slag; soluble in h. acid. Chem. com. 63·6 manganese and 36·4 sulphur. Nagyag and Kapnik, Mexico and Brazil.

480. HAUERITE.—Mn''.

Tesseral; O, $\infty O \infty$, and ∞O. Crystals single or in spherical groups. Cleavage, hexahedral perfect. H. = 4; G. = 3·463. Semitranslucent on very thin edges; metallic-adamantine. Reddish-brown to brownish-black; streak brownish-red. In the closed tube yields sulphur, and leaves a green mass, which B.B. becomes brown on the surface, and is soluble in h. acid. Chem. com. 46·28 manganese and 53·72 sulphur. Kalinka, near Neusohl in Hungary.

481. GREENOCKITE.—Cd'.

Hexagonal and hemimorphic; P 87° 13', 2P 124° 34'. Crystals $2P \cdot 0P \cdot \infty P \cdot P$, or $P \cdot 2\dot{P} \cdot \infty P$; attached singly. Cleavage, ∞P imperfect, basal perfect. H. = 3...3·5; G. = 4·8...4·9. Translucent; brilliant resinous, or adamantine. Honey or orange-yellow, rarely brown; streak yellow. B.B. decrepitates and becomes carmine-red, but again yellow when cold; fused with soda forms a reddish-brown coating

on charcoal; soluble in h. acid. Chem. com. 77·6 cadmium, and 22·4 sulphur. Bishoptown in Renfrewshire.

Family VI.—Ruby-Blendes.

Crystallization rhombohedric, monoclinohedric, or rhombic. Cleavage rarely distinct. H. = 1·5...2·5; G. = 3·5...8·2. Lustre adamantine. Colour yellow, red or gray; streak deep red, rarely brownish or yellow. Soluble in nitric acid. B.B. fusible and reduced often with fumes, or sublime.

*482. Pyrargyrite, Red Silver.—$\dot{A}g^3$ Sb'''.

Rhombohedric; R (*P*) 108° 42′, $-\frac{1}{2}$R 137° 58′, 0R, -2R (*r*), R^3, ∞P2 (*s*), and ∞R (*l*). Crystals prismatic (figs. 252, 253); macles common of various kinds; also massive, den-

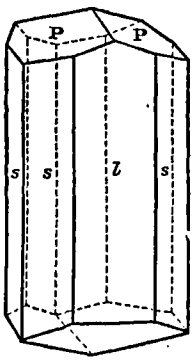


Fig. 252.

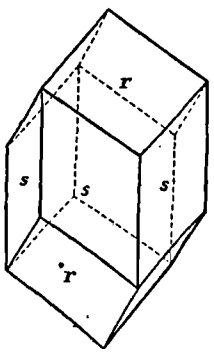


Fig. 253.

dritic, or investing. Cleavage, R rather perfect; fracture conchoidal to uneven and splintery; slightly sectile, sometimes almost brittle. H. = 2...2·5; G. = 5·75...5·85. Translucent on the edges to opaque; crimson-red to blackish lead-gray; streak cochineal to cherry-red. B.B. on charcoal fuses easily, gives out sulphurous acid and antimony fumes, and leaves a grain of silver; soluble in nitric acid, leaving sulphur and antimony protoxide; solution of potash extracts

sulphuret of antimony. Chem. com. 59·8 silver, 22·5 antimony, and 17·7 sulphur. Andreasberg, Freiberg, Johann-Georgenstadt, Annaberg, Schneeberg, and Marienberg; Przibram, Schemnitz and Kremnitz, Markirchen, Kongsberg and Mexico; Huel Brothers and Huel Duchy in Cornwall.

*483. PROUSTITE.—$Ag^{3}\,As'''$.

Rhombohedric, like pyrargyrite, except R, 107° 50′. G. 5·5...5·6. Semitransparent to translucent on the edges. Cochineal to crimson red; streak aurora-red to cochineal-red. B.B. arsenical odour, and leaves a brittle metallic grain difficultly reduced to pure silver; soluble in nitric acid, with remainder of sulphur and arsenious acid; solution of potash extracts sulphuret of arsenic. Chem. com. 65·4 silver, 15·1 arsenic, and 19·4 sulphur. In the same localities with pyrargyrite, and both valuable ores of silver. Red orpiment has a lower specific gravity and yellow streak; cinnabar volatilizes before the blowpipe.

484. MIARGYRITE.—$Ag'\,Sb'''$.

Monoclinohedric; C = 81° 36′, P 90° 53′, −P 95° 59′. Crystals pyramidal, short prismatic, or tabular (fig. 254); also massive. Cleavage, indistinct traces; fracture imperfect conchoidal or uneven; sectile. H. = 2...2·5; G. = 5·3...4. Opaque; thin splinters dark blood-red, translucent; metallic adamantine. Blackish lead-gray to iron-black and steel-gray; streak cherry-red. B.B. with soda, a grain of silver; with acids, like pyrargyrite. Chem. com. 35·9 silver, 42·9 antimony, and 21·2 sulphur. Bräunsdorf near Freiberg.



Fig. 254.

Rittingerite.—Monoclinohedric; C = 88° 26′, ∞P 126° 18′. Crystals small tabular. Cleavage basal imperfect; brittle. H. = 2·5...3. Translucent honey-yellow to red. Colour iron-black, on 0P brown tarnished; streak orange-yellow. B.B. melts easily, with arsenic fumes, leaving much silver. Joachimsthal.

485. XANTHOKON.—$Ag'^3\ As''' + Ag'^3\ As'''$.

Rhombohedric. Crystals very thin hexagonal tables, with R : 0R 110° 30′, −2R : 0R 100° 35′. Cleavage, R and 0R more or less perfect; rather brittle, very easily frangible. H. = 2···2·5; G. = 5·0...5·2. Translucent and transparent; adamantine. Orange-yellow or yellowish-brown; streak slightly darker. In the closed tube fuses very easily, becomes lead-gray. Chem. com. 63·4 silver, 14·7 arsenic, and 21·9 sulphur. Himmelsfürst Mine at Freiberg.

Fireblende.—In thin tabular crystals (like heulandite), with one perfect cleavage; sectile and slightly flexible. G. = 4·2 ...4·3. Hyacinth-red. B.B. like pyrargyrite. Contains sulphur, antimony, and silver. Freiberg and Andreasberg.

486. KERMES.—$Sb'''^2\ \dddot{S}b$.

Monoclinohedric (?). Crystals acicular, capillary, and diverging; also radiating fibrous. Cleavage, very perfect along the axis of the crystals, less perfect at right angles; sectile. H. = 1...1·5; G. = 4·5...4·6. Semitranslucent; adamantine. Cherry-red; streak similar. B.B. acts like stibine; soluble in h. acid; in solution of potash the powder becomes yellow and dissolves. Chem. com. 75·3 antimony, 19·8 sulphur, and 4·9 oxygen; or 70 sulphuret and 30 protoxide of antimony. Bräunsdorf near Freiberg, Przibram, and Allemont.

Zundererz, or Tinder-ore, soft, flexible, tinder-like masses, dirty cherry-red or blackish-red, is a mixture; Andreasberg.

487. CINNABAR.—Hg'.

Rhombohedric; R 71° 48′, 0R $\frac{1}{4}$R, $\frac{1}{8}$R, ∞R. Crystals rhombohedric or thick tabular; also disseminated and granular, compact, or earthy. Cleavage, ∞R rather perfect; fracture uneven and splintery; sectile. H. = 2...2·5; G. = 8...8·2. Semitransparent or opaque; adamantine. Cochineal-red, with lead-gray and scarlet-red tarnish; streak scarlet-red. In the open tube sublimes, partly as cinnabar, partly as metallic mercury; perfectly soluble in

nitrochloric acid, but not in hydrochloric acid, nitric acid, or solution of potash. Chem. com. 86·2 mercury and 13·8 sulphur. Idria in Carniola, Almaden and Almadenejos in Spain, Wolfstein and Moschellandsberg in Rhenish Bavaria, Hartenstein in Saxony, Szlana and Rosenau in Hungary, Ripa in Tuscany; New Almaden in California, Mexico, and Peru. Principal ore of mercury; also used as a pigment. *Fibrous and Hepatic Cinnabar* are mixtures.

488. REALGAR, Red Orpiment.—As″.

Monoclinohedric; C=66° 5′ (*P*), ∞P (*M*) 74° 26′, (P∞) (*n*) 132° 2′, ∞P2 (*l*) 113° 16′. Crystals prismatic (fig. 255); also massive and investing. Cleavage, basal and clinodiagonal rather perfect, prismatic imperfect; fracture small conchoidal to uneven or splintery; sectile. H.=1·5...2; G.=3·4...3·6. Semitransparent or opaque; resinous. Aurora-red; streak orange-yellow. In the closed tube sublimes as a dark-yellow or red mass; B.B. on charcoal fuses and burns with a yellowish-white flame; acids act on it with difficulty. Chem. com. 70 arsenic and 30 sulphur. Kapnik, Nagyag, Felsobanya, and Tajowa, Andreasberg, St Gotthardt, Vesuvius and the Solfatara.

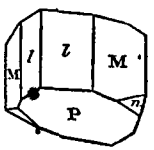


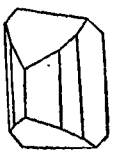
Fig. 255.

489. DIMORPHINE.—As‴.

Rhombic, in two types; more common short prismatic, with ∞P 96° 34′ and P̄∞ 103° 50′; the other more pyramidal. Very fragile. H.=1·5; G.=3·58. Splendent adamantine; translucent or transparent. Orange-yellow; streak similar. Chem. com. 75·5 arsenic, and 24·5 sulphur. Solfatara, Naples.

490. ORPIMENT.—As‴.

Rhombic; ∞P 117° 49′, P̄∞ 83° 37′. Crystals short prismatic (fig. 256), disseminated, columnar or foliated. Cleavage, brachydiagonal very perfect, striated vertically; sectile, and in thin laminæ flexible. H.=1·5...2; G.=3·4...3·5. Semi-


Fig. 256.

transparent or opaque; resinous or pearly. Citron-yellow to orange-yellow. In the closed tube yields a dark-yellow or red sublimate; fused with soda it yields metallic arsenic; soluble in nitrochloric acid, in potash, and in ammonia. Chem. com. 61 arsenic and 39 sulphur. Tajowa near Neusohl, Servia, Wallachia, Natolia, Felsobanya, Kapnik, and Andreasberg; the Solfatara, and Zimapan in Mexico.

ORDER VII.

THE INFLAMMABLES.

Named from the substances all burning before the blowpipe, whereas the former minerals only fused or gave out fumes, and left a residue. Few of them are crystallized, and many rather organic remains or rocks than simple minerals. In chemical composition they are either simple elements, as sulphur and carbon, or mostly formed not on the plan of the mineral kingdom, but of organic nature. Except the diamond, their hardness is low, or less than 2·5; and their specific gravity also 2·2, or under.

FAMILY I.—SULPHUR.

*491. SULPHUR.—S.

Rhombic; P polar edges 106° 38′, 84° 58′, middle edge 143° 17′; ∞P 101° 58′, 0P, ½P, P̆∞. Crystals pyramidal (fig. 257), single or in druses; also reniform, spherical, stalactitic, disseminated, incrusting, or pulverulent. Cleavage, basal and ∞P imperfect; fracture conchoidal to uneven or splintery; rather brittle. H.=1·5

...2·5 ; G.=1·9...2·1. Transparent or translucent on the edges ; resinous or adamantine. Sulphur-yellow, passing into brown and red, or into yellowish-gray and white. In the closed tube it sublimes ; at 227° Fahr. fuses, and at 518° takes fire and burns with a blue flame, forming sulphurous acid. Chem. com. sulphur, occasionally more or less mixed with other substances. Sicily, at Girgenti, Cataldo, &c. ; the Lipari Islands, the Solfatara near Naples, Poland, Iceland, Java, Sandwich Islands, Peru, and Chili ; from springs at Aix-la-Chapelle, and in Scotland.

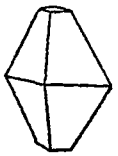


Fig. 257.

492. SELEN-SULPHUR.

Orange-yellow or yellowish-brown. Fuses readily in the closed tube, and volatilizes. B.B. on charcoal burns, and gives out fumes of selenic and sulphurous acids. Consists of sulphur and selenium. Vulcano, Lipari, and Kilauea in Hawai.

Native Selenium.—Brownish-black or lead-gray. Thin splinters red translucent. H.=2 ; G.=4·3. Culebras in Mexico.

FAMILY II.—DIAMOND.

*493. DIAMOND.—C.

Tesseral and tetrahedral-semitesseral ; $\frac{O}{2}$ and $-\frac{O}{2}$, mostly conjoined, ∞O, ∞On, mO, mOn ; or the octahedron, rhombic dodecahedron, and hexakisoctahedron (figs. 2, 3, 7, and 5). The crystals have often curved faces, and occur loose or imbedded singly. Macles common, united by a plane of O, like fig. 251. Cleavage, octahedral perfect ; fracture conchoidal ; brittle. H.=10 ; G.=3·5 ...3·6. Transparent or translucent when dark-coloured Refracts light strongly ; brilliant adamantine. Colourless, but often white, gray, or brown tints, also green, yellow

red, blue, and rarely black. Becomes positive electric by friction; burns in oxygen gas, and forms carbonic acid. Chem. com. pure carbon. Hindostan on the east of the Deccan, between Pennar, Sonar, and the delta of the Ganges (lat. 14° to 25°); Borneo and Malacca; Brazil in the district of Serro do Frio in Minas Geraes; also in Borneo, Malacca, the Ural, Georgia, and North Carolina, and the Sierra Madre, south-west from Mexico.

*Family III.—The Coals.

*494. Graphite, Plumbago.—C.

Hexagonal or monoclinohedric; but only thin tabular or short prismatic crystals of 0P . ∞P. Usually foliated, radiating, scaly, or compact. Cleavage, basal perfect; very sectile, flexible in thin laminæ. Feels greasy. H.=0·5...1; G.=1·9...2·2. Opaque; metallic. Iron-black. Leaves a mark on paper. Is a perfect conductor of electricity. B.B. burns with much difficulty; and heated with nitre in a platina spoon only partially detonates. Chem. com. carbon, but mixed with iron, lime, alumina, or other matter. Pargas, Arendal, Passau, Spain, Ticonderoga in New York, Ceylon, Borrowdale in Cumberland, Glenstrathfarrer in Inverness-shire, Kirkcudbright, and Craigman in Ayrshire. At the latter it is evidently common coal altered by contact with trap. Is used for making pencils, and to form crucibles.

*495. Anthracite.—Glance-Coal.

Massive and disseminated; rarely columnar, or fibrous and pulverulent. Fracture conchoidal; brittle. H.=2...2·5; G.=1·4...1·7. Opaque; brilliant metallic. Iron-black or grayish-black; streak unaltered. Perfect conductor of electricity. Burns difficultly with a very weak or no flame, and does not cake; in the closed tube yields a little moisture, but no empyreumatic oil; detonates with

nitre. Chem. com. carbon above 90 per cent., with 1 to 3 oxygen, 1 to 4 hydrogen, and 0 to 3 nitrogen; and ashes chiefly of silica, alumina, lime, and peroxide of iron. Very common in some parts of the English, Scottish, and Irish coal-fields; in the Alps, as the Valais, Piedmont, Savoy, and Dauphiné; in the Pyrenees, and in various parts of France; in Silesia, Bohemia, Saxony, and the Harz; and in the United States, as in Rhode Island, Massachusetts, and above all in Pennsylvania. Used for manufacturing metals, and for economic and household purposes.

**496. COMMON COAL, Black, Stone, Bituminous Coal.

Compact, slaty, or confusedly fibrous; often dividing into columnar, cubical, or rhomboidal fragments. Fracture conchoidal, uneven, or fibrous; rather brittle or sectile. H.=2...2·5; G.=1·2...1·5. Vitreous, resinous, or silky in the fibrous variety. Blackish-brown, pitch-black, or velvet-black. Burns easily, emitting flame and smoke, with a bituminous odour; heated in the closed tube with powdered sulphur gives out sulphuretted hydrogen. Chem. com. 74 to 90 carbon, with 0·6 to 8 or 15 oxygen, 3 to 6 hydrogen, 0·1 to 2 nitrogen, 0·1 to 3 sulphur, and 1 to 11 earthy matters or ash, in 100 parts.

Slate-coal has a thick slaty structure, and an uneven fracture in the cross direction. *Cannel coal*, a resinous, glimmering lustre, and a large or flat conchoidal fracture; breaks into irregular cubical fragments, but more solid, and takes a higher polish than the other varieties. It burns with a bright flame, and yields much gas. *Coarse* or *foliated coal*, massive or lamellar, breaks into cubical or irregular angular masses, with a more splendent lustre, and less compact texture than the former, and more easily frangible. *Earthy coal*, loose powdery masses, often brown or dirty in colour, and apparently semi-decomposed. Abundant in many lands, as in England, South Wales, Scotland, and Ireland; in Belgium and France, in Germany and Southern Russia. The United States possess immense fields in the

valley of the Mississippi. Also found in China, Japan, Hindostan, Australia, Borneo, and several of the Indian Islands. Its uses are too well known to need notice.

*497. BROWN COAL.—Lignite, Jet.

Distinctly vegetable in origin, the external form, and very often the internal woody structure, being preserved. The texture is compact, woody, or earthy. Fracture conchoidal, woody, or uneven; soft and often friable. G.= 0·5...1·5. Lustre sometimes resinous, mostly glimmering or dull. Brown, black, or rarely gray. Burns easily with an unpleasant odour; colours solution of potash deep-brown; heated with sulphur evolves much sulphuretted hydrogen. Chem. com. 47 to 73 carbon, 2·5 to 7·5 hydrogen, 8 to 33 oxygen (with nitrogen), and 1 to 15 ashes. *Jet* is pitch-black, with conchoidal fracture and resinous lustre. Brown coal occurs at Bovey Tracy in Devonshire, in Yorkshire, Antrim, Brora, Mull, and Skye; Germany, Hungary, France, Italy, and Greece. The *Surturbrand* of Iceland seems a variety. Used as fuel, but much inferior to common coal.

*498. PEAT.

A mass of more or less decomposed vegetable matter of a brown or black colour, closely connected with coal, and, like it, rather a rock than a simple mineral. Contains 50 to 60 carbon, 5 to 6 hydrogen, 30 to 39 oxygen, 0 to 2 nitrogen, and 1 to 14 ashes in 100 parts. Common everywhere in the colder parts of the earth.

FAMILY IV.—THE MINERAL RESINS.

*499. BITUMEN, Naphtha.—CH^2.

Liquid. Colourless, yellow, or brown; transparent or translucent. G.=0·7...0·9. Volatilzes in the atmosphere with an aromatic bituminous odour. Chem. com. 84 to 88 carbon, and 12 to 16 hydrogen.

Naphtha.—Very fluid, transparent, and light-yellow.

Tegern Lake in Bavaria, Amiano near Parma, Salies in the Pyrenees, Rangun in Hindostan, Baku on the Caspian Sea, China, Persia, and North America. Used for burning and preparing varnishes. *Petroleum.*—Darker yellow or blackish-brown; less fluid or volatile. Ormskirk in Lancashire, at Coalbrookdale, Pitchford, and Madeley in Shropshire; St Catherine's Well, south of Edinburgh; Isle of Pomona; and in many other parts of Europe and the United States.

*500. ELATERITE, Elastic Bitumen, Mineral Caoutchouc. } CH^2.

Compact; reniform or fungoid; elastic and flexible like caoutchouc; very soft. G.=0·8...1·23. Resinous. Blackish, reddish, or yellowish brown. Strong bituminous odour. Chem. com. 84 to 86 carbon, 12 to 14 hydrogen, and a little oxygen. Derbyshire, Montrelais near Nantes, and Woodbury in Connecticut.

501. ASPHALTUM.

Compact and disseminated. Fracture conchoidal, sometimes vesicular; sectile. H.=2; G.=1·1...1·2. Opaque, resinous, and pitch-black; strong bituminous odour, especially when rubbed. Takes fire easily, and burns with a bright flame and thick smoke; soluble in ether, except a small remainder, which is dissolved in oil of turpentine. Chem. com. 76 to 88 carbon, 2 to 10 oxygen, 6 to 10 hydrogen, and 1 to 3 nitrogen. Limmer near Hanover, Seyssel on the Rhone; Val Travers in Neufchatel, Lobsann in Alsace, in the Harz; Cornwall, Haughmond Hill, Shropshire; East Lothian, Burntisland in Fifeshire; Dead Sea, Persia, and Trinidad.

502. PIAUZITE.

Massive; imperfect conchoidal; sectile. H.=1·5; G.=1·22. Dimly translucent on very thin edges; resinous. Blackish-brown; streak yellowish-brown. Fuses at 600° Fahr., and burns with an aromatic odour, lively flame,

and dense smoke; soluble in ether and caustic potash. Piauze in Carniola.

503. IXOLYTE.

Massive; conchoidal fracture. H.=1; G.=1·008. Resinous. Hyacinth-red; streak ochre-yellow. Rubbed between the fingers it emits an aromatic odour, and becomes soft at 119°, but is still viscid at 212°. Oberhart near Gloggnitz in Austria.

*504. AMBER, Succinite.—C^{10} H^8 O.

Round irregular lumps, grains, or drops. Fracture perfect conchoidal; slightly brittle. H.=2...2·5; G.=1... 1·1. Transparent to translucent or almost opaque; resinous. Honey-yellow, but from hyacinth-red or brown to yellowish-white; also streaked or spotted. When rubbed emits an agreeable odour, and becomes negatively electric. It melts at 550°, emitting water, an empyreumatic oil, and succinic acid; it burns with a bright flame and pleasant odour, leaving a carbonaceous remainder; only a small part is soluble in alcohol. Chem. com. 79 carbon, 10·5 hydrogen, and 10·5 oxygen. Derived from an extinct coniferous tree, and found in the diluvial formations of many countries, especially Northern Germany and shores of the Baltic, Sicily, Spain, and Northern Italy; rarely in England, as on the shores of Norfolk, Suffolk, and Essex, and at Kensington near London. Used for ornamental purposes, and for preparing succinic acid and varnishes.

505. RETINITE, Retinasphalt.

Roundish or irregular lumps. Fracture uneven or conchoidal; very easily frangible. H.=1·5...2; G.=1·05...1·15. Translucent or opaque; resinous or glistening. Yellow or brown. Melts at a low heat, and burns with an aromatic or bituminous odour. Chem. com. in general carbon, hydrogen, and oxygen, in very uncertain amount. Bovey, Halle, Cape Sable, and Osnabrück.

506. WALCHOWITE.—C^{12} H^9 O.

Rounded pieces, with a conchoidal fracture. H.=1·5...

2; G.=1·035...1·069. Translucent, resinous. Yellow with brown stripes; and a yellowish-white streak. It fuses at 482°, and burns readily; soluble partially (7·5 per cent.) in ether, and in sulphuric acid forms a dark-brown solution. Chem. com. 80·4 carbon, 10·7 hydrogen, and 8·9 oxygen. Walchow in Moravia.

507. COPALINE, Fossil Copal, Highgate Resin. $C^{40}\ H^{64}\ O$.

Irregular fragments. H.=1·5; G.=1·046. Translucent, resinous, and light-yellow or yellowish-brown. Burns easily with a bright-yellow flame and much smoke; alcohol dissolves very little of it, which is precipitated by water; becomes black in sulphuric acid. Chem. com. 85·54 carbon, 11·63 hydrogen, 2·76 oxygen. Highgate near London. A similar resin from Settling Stones in Northumberland, found in flat drops or crusts on calc-spar, is infusible at 500° Fahr.; G.=1·16...1·54: and contains 85·13 carbon, 10·85 hydrogen, and 3·26 ashes; or $C^2\ H^3$.

508. BERENGELITE.—$C^{40}\ H^{62}\ O^8$.

Amorphous; conchoidal fracture. Dark-brown, inclining to green; yellow streak. Resinous; unpleasant odour, and bitter taste. Fuses below 212°, and then continues soft at ordinary temperatures; easily soluble in alcohol. Chem. com. 72·40 carbon, 9·28 hydrogen, 18·31 oxygen. St Juan de Berengela in South America.

509. GUYAQUILLITE.—$C^{20}\ H^{26}\ O^3$.

Amorphous; yielding easily to the knife, and very friable. G.=1·092. Pale yellow. Slightly resinous. Fluid at 212°, viscid when cold; slightly soluble in water and largely in alcohol, forming a yellow fluid with a bitter taste. Chem. com. 77·01 carbon, 8·18 hydrogen, and 14·80 oxygen. Guyaquil in South America.

Bogbutter, from the Irish peat mosses, is similar; melts at 124°, easily soluble in alcohol, and contains 73·70 carbon, 12·50 hydrogen, and 13·72 oxygen.

510. HARTINE.—C^{20} H^{34} O^2.

Spermaceti-like masses. G.=1·115. White; without taste or smell. Becomes soft at 392°, and at 410° melts to a clear yellow fluid; burns with a bright flame; it is not soluble in water, very little in ether, and less in alcohol. Chem. com. 78·26 carbon, 10·92 hydrogen, 10·82 oxygen. Oberhart in Austria.

511. MIDDLETONITE.—C^{20} H^{20}+HO.

Round masses or thin layers. Brittle, but easily cut with a knife. G.=1·6. Resinous. Reddish-brown by reflected, deep-red by transmitted light; streaked, light-brown. It becomes black on exposure to the atmosphere. Chem. com. 86·44 carbon, 8·01 hydrogen, 5·56 oxygen. In the main coal seam at Middleton near Leeds, and at Newcastle.

512. OZOKERITE.—CH.

Amorphous, sometimes fibrous. Very soft, pliable, and easily fashioned with the fingers. G.=0·94...0·97. Glimmering or glistening; semitranslucent. Yellowish-brown or hyacinth-red by transmitted, dark leek-green by reflected light. Pleasant aromatic odour; fuses easily (at 144°, *Schrötter*; at 183°, *Malagutti*) to a clear oily fluid, again becoming solid when cold, and at higher temperatures burns with a clear flame, seldom leaving any ashes; readily soluble in oil of turpentine, with great difficulty in alcohol or ether. Chem. com. 85·7 carbon, and 14·3 hydrogen. Slanik and Zietriska in Moldavia, and near Garning in Austria. Also Urpeth coal mine near Newcastle-on-Tyne.

513. HATCHETINE, Mineral Tallow.

Flaky, like spermaceti; or sub-granular, like bees' wax; soft and flexible. G.=0·6. Translucent; weak pearly. Yellowish-white, wax-yellow, or greenish yellow. Greasy; inodorous; readily soluble in ether. Chem. com. 85·91 carbon, and 14·62 hydrogen, or similar to ozokerite. Glamorganshire (fusible at 115°); Loch Fyne near Inverary.

Also Merthyr-Tydvil (melts at 170°), and Sooldorf in Schaumburg.

514. FICHTELITE.—C^4 H^6.

Crystalline lamellæ, which swim in water, but sink in alcohol. White and pearly. Fuse at 115°, but again become crystalline on cooling; very easily soluble in ether, and precipitated by alcohol. Chem. com. 89·3 carbon and 10·7 hydrogen. In pine trees in a peat moss near Redwitz in Bavaria.

515. HARTITE.—C^6 H^5.

Resembles spermaceti or white wax; lamellar, and probably monoclinohedric. Sectile, but not flexible. H.=1; G.=1·046. Translucent; dull resinous. White. Melts at 165°, and burns with much smoke; very soluble in ether, much less so in alcohol. Chem. com. 87·50 carbon, and 12·10 hydrogen. Oberhart in Austria.

516. KÖNLITE.—C^2 H.

Crystalline foliæ and grains. Soft. G.=0·88. Translucent; resinous. White, without smell. Fuses at 120° to 137° Fahr; soluble in nitric acid, and precipitated by water in a white crystalline mass. Chem. com. 92·31 carbon and 7·69 hydrogen. Uznach near St Gallen, Redwitz in Bavaria.

517. SCHEERERITE.—CH^2.

Monoclinohedric; tabular or acicular. Soft and rather brittle. G.=1·0...1·2. Translucent; resinous or adamantine. White, inclining to yellow or green. Feels greasy, has no taste, and when cold no smell, but when heated a weak aromatic odour. Insoluble in water; but readily in alcohol, ether, nitric, and sulphuric acid. Chem. com. 75 carbon, and 25 hydrogen. Uznach. *Branchite*, white, translucent, feels greasy, and fuses at 167°, is similar; Monte Vaso in Tuscany.

518. IDRIALITE.—(Idrialine = C^{12} H^{14} O).

Massive; fracture uneven or slaty. Sectile. H.=1·0... 1·5; G.=1·4...1·6 (1·7...3·2). Opaque; resinous. Gray-

ish or brownish-black; streaked blackish-brown, inclining to red. Feels greasy. Burns with a thick smoky flame, giving out sulphurous acid, and leaving some reddish-brown ashes. Chem. com. idrialine (=91·83 carbon, 5·30 hydrogen, and 2·87 oxygen) and cinnabar, with a little silica, alumina, pyrite, and lime. The idrialine may be extracted by warm olive oil or oil of turpentine, as a pearly shining mass. Idria.

Family V.—Inflammable Salts.

519. Mellite, Honey Stone.—$\ddot{A}l\,\bar{M}^3 + 18\,\dot{H}$.

Tetragonal; P 93° 6′. Crystals, P alone, or with 0P, P∞, and ∞P∞, usually single; also massive and granular. Cleavage, P very imperfect; fracture conchoidal; rather brittle. H.=2·0...2·5; G.=1·5...1·7. Transparent to translucent; distinct double refraction; resinous or vitreous. Honey-yellow to wax-yellow or reddish; streak whitish. In the closed tube it yields water. B.B. carbonizes without any sensible odour, at length burns white, and acts like pure alumina; easily soluble in nitric acid or solution of potash. Chem. com. 40·53 mellic acid ($\bar{M} = C^4\,O^3$), 14·32 alumina, and 45·15 water. Artern in Thuringia, Lauschitz in Bohemia, and Walchow in Moravia.

520. Oxalite, Humboldtine.—$2\,\dot{F}e\,\ddot{C}^3 + 3\,\dot{H}$.

Capillary crystals; also botryoidal or in plates, and fine granular, fibrous, or compact. Fracture uneven or earthy; slightly sectile. H.=2; G.=2·15...2·25. Opaque; weak resinous or dull. Ochre or straw yellow. B.B. on charcoal becomes first black then red; easily soluble in acids. Chem. com. 42·7 oxalic acid, 41·4 iron protoxide, and 15·9 water. Kolosoruk near Bilin, Duisburg, and Gross Almerode in Hessia.

521. WHEWELLITE.—$\dot{Ca}\dddot{C}+7$ H.

Monoclinohedric; C = 72° 41′, ∞P 100° 36′. Cleavage, basal perfect; very brittle. H. = 2·5...2·8; G. = 1·833. Transparent to opaque; vitreous. Colourless. Chem. com. 49·31 oxalic acid, 38·36 lime, 12·33 water. Hungary (?).

522. CONISTONITE.—$\dot{Ca}\dddot{C}+7\dot{H}$.

Rhombic; ∞P 97° 5′. Slightly sectile. H. = 2; G. = 2·052. Transparent to translucent; vitreous. Colourless. Soluble without effervescence in n. acid. Chem. com. 28·1 oxalic acid, 21·8 lime, and 50·1 water. Coniston in Cumberland.

Though properly not a simple mineral, the characters of water in its two conditions may be noted here.

*523. WATER.—HO.

Fluid and amorphous. G. = 1·000 when pure, but sea-water 1·027 and 1·0285 at 62° Fahr. When pure it is without taste or smell, and colourless in small quantities, but in larger masses green or blue. Chem. com. hydrogen-oxide, with 88·9 oxygen and 11·1 hydrogen. Attains its greatest density at 39°·1, boils at 212°, and at 32° Fahr. freezes and changes to

ICE.

Rhombohedric; R 117° 23′ (120°); usually six-sided tables of 0R . ∞R; also acicular crystals, macled in delicate groups or stars with six rays. Cleavage, probably basal. H. = 1·5; G. = 0·9268 (*Ossann*), 0·918 (*Brunner* at 32° Fahr., and quite pure). Transparent; vitreous. Colourless, but in large masses greenish or bluish. Refracts double.

The water found on the earth is never pure, but contains more or less of various substances,—atmospheric air, car-

bonic acid, nitrogen gas; silica, alumina, and salts (carbonates, sulphates, nitrates, phosphates) of lime, magnesia, soda, potash, protoxides of iron and manganese; or chlorides, and fluorides of the metallic bases; and in the sea and some saline springs also iodine and bromine.

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